UNIVERSITY OF ALBERTA

Sod Salvage And Minimal Disturbance Pipeline Reclamation Techniques: Implications For Native Prairie Restoration

by

Wilfred Lane Petherbridge ©

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of
the requirements for the degree of Master of Science

in

Land Reclamation and Remediation

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FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled Sod Salvage And Minimal Disturbance Pipeline Reclamation Techniques: Implications For Native Prairie Restoration submitted by Wilfred Lane Petherbridge in partial fulfillment of the requirements for the degree Master of Science in Land Reclamation and Remediation.

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ABSTRACT

Research was conducted to evaluate two atypical pipeline construction and reclamation techniques aimed at hastening restoration of disturbed native prairie. One involved salvaging the native prairie sod from the pipeline right-of-way prior to construction and subsequently replacing it. The other minimized the initial disturbance by restricting soil disturbance to the pipeline trench with the balance of construction activities directly on the prairie surface. The research also involved evaluating seeding versus not seeding the disturbed areas and examined the contribution made by the seedbank to the revegetation process.

Results indicate that sod salvage is an effective prairie reclamation technique although success varies with the nature of the predisturbance plant community. Minimizing initial disturbances is clearly advantageous in hastening restoration but should be done in conjunction with topsoil conservation, when possible. Seeding appropriate native grasses is beneficial. The seedbank contributed to rapid ground cover but few desirable perennial native species emerged.

A thing is right when it tends to preserve
the integrity, stability, and beauty of the biotic community.
It is wrong when it tends otherwise.
Aldo Leopold

This thesis is dedicated to my life-mate
Jocelyne Marie Lafleche
and to our children
Sophie Jeanne Lafleche-Petherbridge
and
Pascal Lawson Lafleche-Petherbridge
who, together,
make it all worthwhile.

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I. INTRODUCTION

1.0 Background

A variety of development pressures, from natural resource energy extraction and transportation and from agriculture, are currently being exerted upon native prairie ecosystems. Thus reclamation practices aimed at restoration of disturbed ecosystems are being encouraged by provincial and federal regulatory agencies. Reclamation of native ecosystems can be described as managed plant succession whereby attempts are made to promote the development of late seral stage plant communities in relatively short time frames (Allen 1988). Understanding successional processes is therefore essential where restoration of the original ecosystem is desired.

Clements (1916) describes plant succession as the successive replacement of one plant community with another as vegetation develops. The plants of each successive wave of vegetation alter the environment to make it fit for the next plant community but unfit for the current one (Clements 1928). Connell and Slatyer (1977) describe this process as the facilitation model of plant succession. Whether succession occurred on previously unvegetated, bare substrate (primary succession) or on previously vegetated but subsequently disturbed land (secondary succession) Clements postulated succession would eventually lead to the development of specific, stable plant communities whose structure is controlled by the prevailing climate. In the absence of anthropogenic disturbances or great climatic change these climax plant communities would exist indefinitely (Clements 1936). Clements also postulated that successive plant communities were identifiable and distinct.

Booth (1941) studied plant community development on abandoned farmland in Oklahoma and Kansas. He proposed four distinct stages of succession progressing from weeds to annual grasses to perennial bunch grasses and eventually to fully developed mature prairie. Attainment of the latter was only hypothesized as he studied fields up to 30 years post-abandonment that did not appear to be nearing mature prairie.

Opposition to the Clementsian view that plant communities are distinct, organic entities and that plant succession followed an orderly, predictable pattern began almost immediately following his 1916 publication. Gleason (1917) argued that vegetation is not composed of distinct organic entities but rather depends upon environmental selection of favored individuals and plant succession was a less orderly, evolutionary process culminating in dynamic equilibrium with the environment as a whole. Costello (1944), examining natural succession on abandoned prairie farmland, found many pioneering annual species persisted throughout succession and were present in the mixed prairie association that eventually developed. He also reported that, in some cases, many perennial grasses commonly found in mature mixed prairie appeared very early after abandonment in association with annual weeds. However, the purpose of this review is not to argue for or against any theory of plant community development but to discuss a variety of influencing factors emphasizing secondary plant succession on industrially disturbed native prairie ecosystems.

2.0 Initial Disturbance Conditions

Successional processes are initiated by some perturbation of an otherwise stable plant community (Connell and Slatyer 1977). If plant community structure is directly related to the distribution of and competition for resources as suggested by Tilman (1982) it follows that the nature and extent of a disturbance and resulting initial conditions upon which successional processes will act can have a profound effect on the rate, trajectory and eventual outcome of the succession.

In a study of succession on four levels of disturbance on sagebrush-grassland in Colorado, Doerr et al. (1984) found a negative correlation between perennial grass canopy cover and above ground biomass and degree of disturbance. The opposite relationship was found between annual forbs (primarily russian thistle (*Salsola kali* L.)) and the degree of disturbance. The degree of disturbance affected soil fertility, soil water holding capacity, the number of naturally occurring seeds and rhizomes and the amount of mycorrhizal fungi. Differences in the developing plant community were attributed to the combination of all those factors.

Belsky (1986a), examining the effect of disturbance on revegetation found differences in density and species composition of colonizing plants depending on depth of disturbance. Deep disturbances, where 15 cm of soil were broken and mixed and all plant parts were removed, favored establishment of sexually reproducing plants. Vegetatively reproducing species established more readily on shallow disturbances, where only the top 1 to 2 cm of soil was disturbed. She concluded that the deep disturbance created a fertile seedbed for establishing seedlings and that underground plant organs had not been removed from shallowly disturbed plots that aided their re-establishment. She also states that had the disturbances been deep enough to alter surface soil chemistry or texture the results may have been different.

Industrial activity has many other effects on soils. For example, Smith et al. (1988) found higher bulk density and pH on soils disturbed by petroleum drilling activities in Wyoming compared to nearby undisturbed soils. Soil electrical conductivity (EC), sodium absorption ratio (SAR) and cation exchange capacity (CEC) were not affected. Slower recovery of vegetation to predisturbance conditions was noted on soils with the greatest increase in pH and it was suggested elevated pH prevented establishment of nearby late seral species. Disturbed soils also had shallower effective rooting depths than undisturbed controls.

Naeth et al. (1987) found pipeline construction in Solonetzic mixed prairie reduced soil quality by increasing bulk density (except over the trench), reducing organic matter and increasing surface salts. Chemical changes tended to ameliorate with time, closely resembling the undisturbed prairie within twenty years. Total soil water increased to a depth of 50 cm in the trench compared to the undisturbed prairie (Naeth et al. 1988). There were no significant effects on available water capacity.

3.0 Plants and Plant Attributes in the Disturbed Community

In a comprehensive review of relevant research Grime (1977) presents evidence for the existence of three broad categories of plants, each with distinctive characteristics which allow members of the groups to survive varying degrees of disturbance and stress. Stress is defined as any condition that restricts plant biomass production (e.g. low levels of nutrients, light, water) and disturbance refers to destruction of plant biomass whether through herbivory, disease or humans. Expression of the survival traits is primarily a function of environment that selects suitable species from the different groups.

Competitive plants thrive only in environments of low stress and low disturbance which allows them to express their superior abilities to extract high levels of moisture and nutrients below ground and hence compete effectively for light and space above ground (Grime 1977). Stress tolerant plants are those adapted to survive in environments deficient in one or more of the constituents upon which competitive plants thrive. Evidence suggests that stress tolerance is a function of the ability to conserve the limiting resource rather than the ability to maximize its capture. The third broad category of plants proposed by Grime (1977) contains those species adapted to high levels of disturbance. These are the ruderals. They generally have common features: a short life span, the ability to grow and mature rapidly and the ability to direct photosynthate away from vegetation to seed production under conditions of stress. Another important attribute of ruderals is longevity of buried seeds which is particularly important under conditions of frequent and severe disturbance like cultivation.

When plant taxa are grouped according to the above characteristics, recognizing that most plants are adapted to intermediate degrees of competition, stress and disturbance, the group occupying the most space between the three extremes is perennial herbs and ferns (Grime 1977). Excluding ferns, this group encompasses the majority of plants found in prairie ecosystems today. Furthermore, as pointed out by Connell and Slatyer (1977), circumstances must exist that support all plant species indefinitely, otherwise they would go extinct. In the case of early successional (ruderal) species either disturbances must be frequent enough and large enough to support those species or they occupy a different successional position in a plant community elsewhere. In other words, some species fall into more than one slot in the successional ladder depending on their current environments. Grime (1979) suggests that many species may be common to both early and late seral stages in grass or shrubland communities. This feature of prairie plants may explain the indefinite nature of seral stages reported by Costello (1944) and others (Egler 1954, Collins and Adams 1983). So the majority of prairie plants are simultaneously adapted to varying degrees of competition, stress and disturbance but different species express varying degrees of those adaptations.

In a study of 24 common, rhizomatous prairie plants Mueller (1941) found that despite similar growth forms certain species, notably western wheatgrass (*Agropyron smithii* Rydb.), was able to gain and retain more area than other species; its rhizomes simply grew more quickly than those of its competitors. Retention of gained area was attributed to the long living nature of the rhizomes. Rhizomes of certain species were also able to withstand greater periods of desiccation and to survive and grow through deeper soil deposits. Western wheatgrass was able to grow through 30 cm of soil compared to big bluestem (*Andropogon furcatus* Muhl.) that survived only 8 cm of soil cover. Similar differences were found among the forbs studied.

Expression of adaptations is also subject to change with environmental conditions (Grime 1977). For example, Allen (1982) found that competition between russian thistle and two common prairie grasses varied with soil moisture conditions. In dry soil, western wheatgrass produced significantly greater biomass when grown alone than when growing with russian thistle but under moist conditions russian thistle had no effect. Blue grama grass (*Bouteloua gracilis* (HBK) Lag.) followed the same pattern. Both grasses grew more under wet conditions but russian thistle produced more biomass under dry conditions. Under dry conditions, russian thistle also grew more in competition with a grass than it did in monoculture.

Pasture sage (*Artemisia frigida* Willd.) is another example of flexible adaptation. Due to its ability to adapt root development to varying soil moisture conditions, pasture sage is a very successful, and therefore common, western Canadian prairie plant. When moisture is deep within the soil profile, pasture sage develops a taproot but grows shallow roots to capture near surface moisture when it prevails (Coupland and Johnson 1965).

4.0 Propagule Sources

When revegetation occurs naturally, surrounding vegetation is the source of propagules and therefore dictates which species are available to colonize and eventually stabilize a disturbance. Developing plant communities on old fields in North America bear little resemblance to the prairie grasslands nearby for many years (Booth 1941, Costello 1944), whereas disturbances in the Serengeti (Belsky 1986b) were colonized and stabilized within a few years with species common to the mature grassland directly adjacent to them. This suggests that the structure of the surrounding vegetation, acting as a source of propagules, is a significant determinant of the rate and trajectory of succession.

If the goal of revegetation is a plant community identical to surrounding vegetation then it may be appropriate to simply wait for it to develop. However, in western Canada, 40 years or more may be required to complete the process (Coupland 1950). This time frame may be unacceptable, for example, if native prairie is being grazed by domestic animals or if industry is seeking release from environmental liability (reclamation certification) quickly after site reclamation.

The process may be delayed further or completely arrested if inhibitory species become established (Connell and Slatyer 1977). Typically these are early to mid successional perennials that can quickly secure open space and hold it indefinitely thereby preventing invasion by later seral species. This is especially true if the inhibitors can propagate both vegetatively and sexually. On a block of heavily grazed pasture adjacent to undisturbed prairie 30 years after they were fenced together and preserved, Glenn-Lewin (1980) found that although the native prairie had moved into the disturbed area, the rate of change was extremely slow and concentrated along the boundary between the two plant communities. The disturbed area was dominated by kentucky bluegrass (*Poa pratensis* L.) and smooth brome (*Bromus inermis* Leyss.), both rhizomatous perennials. Similar results have been recorded in southern Alberta where Dormaar et al. (1994) found that blue grama grass swards resist displacement by associated grass species. According to Connell and Slatyer (1977) the opportunities for a new seedling to become established in a dense grass sward are virtually zero. Glenn-Lewin (1980) drew two interesting conclusions from his work: the rate of revegetation on disturbed grasslands is very slow and it is unlikely that abandoned areas will ever get to a native prairie stage unless the area is adjacent to native prairie or is intentionally planted.

Seeding disturbances following soil reclamation is common practice today and is legislated in many North American jurisdictions. Originally seeding was intended to stabilize the soil surface to prevent erosion and to hasten the return to predisturbance land use (i.e. grazing). Little attention was paid to species selection. However, many studies have shown that inappropriate species selection is tantamount to intentional establishment of the inhibitory species of Connell and Slatyer (1977) when site restoration is the goal (Sindelar 1978, Schuman et al. 1982, Smith et al. 1988). Not only have seeded non-native species retarded the re-establishment of native species, but in some cases have actually invaded the surrounding, undisturbed ecosystem. Naeth (1985) found crested wheatgrass (*Agropyron pectiniforme* R. & S.) growing in native prairie outside the pipeline right-of-way in southern Alberta where it had been planted. Gill (1996) reported similar findings outside wellsites where crested wheatgrass had been seeded. However, Smith et al. (1988) found that although seeded non-native grasses appeared to suppress invasion of the surrounding sagebrush-grassland vegetation they did not completely inhibit establishment of some native forbs. In a coniferous forest nearby they found that seeded non-native grasses promoted establishment of native forbs and shrubs at the expense of trees.

More recently, revegetation has become an effort to encourage plant succession and accelerate site restoration. This has usually been attempted by seeding late seral grasses (Allen 1988) and in some cases forbs and shrubs common to undisturbed vegetation nearby. Establishing diverse native plant communities from seed has proved difficult, however. Redente et al. (1984) compared plant community development after seeding disturbed plots with six different seed mixes containing various combinations of native and non-native grasses, shrubs and forbs and found that, after five years, all stands were dominated by grasses regardless of the composition of the seed mix. Species diversity of plots seeded with native species was greater compared to non-native plots but no seeded plots approached the diversity of undisturbed vegetation. This study also suggests that common cultural practices, such as fertilizer application, favor rapid establishment and growth of grasses over forbs and shrubs.

In south eastern Alberta, Gill (1996) found naturally revegetated disturbances more similar to adjacent undisturbed prairie than wellsites seeded with native plant species. Interestingly, a 47 year old abandoned field was more similar to its associated plant community than was a 75 year old abandonment. Although there were more non-seeded shrubs and forbs on old-seeded compared to young-seeded wellsites the difference was not statistically significant. However, a relatively small age difference separated young (1 to 3 growing seasons post seeding) from old (4 to 7 growing seasons post seeding) sites.

5.0 Climate and Weather

North American grasslands are characterized by a paucity of moisture and although native vegetation is well adapted to dry conditions, patterns of precipitation can have a profound effect on the nature of plant communities. As reported in Coupland (1950), a study conducted by Clarke et al. (1943) which spanned the period of great drought on the Canadian prairies reported decreases in density of blue grama grass, needle and thread (*Stipa comata* Trin. & Rupr.), western wheatgrass and pasture sage and simultaneous increases in density of smaller species like sandberg's bluegrass (*Poa sandbergii* Vasey), moss phlox (*Phlox hoodii* Richards.) and little club moss (*Selaginella densa* Rydb.). Unfortunately, the study was not continued following the drought.

Weaver (1954) documented changes to a true prairie plant community that occurred over a 17 year period beginning with three years of severe drought followed by favorable growing conditions. During the drought big bluestem (*Andropogon gerardii* Michx.) and little bluestem (*Andropogon scoparius* Michx.) declined while drought resistant sand dropseed (*Sporabolus cryptandrus* Torr.) and side oats grama (*Bouteloua curtipendula* (Michx.) Torr.) increased. Following the drought this pattern reversed and the original dominants regained lost ground.

Developing plant communities are also affected by weather. Blake (1935) did an extensive study of germination and early life history of a variety of native prairie plants in Nebraska that shows how different weather conditions might influence different species at different stages of early growth. For example, the process of seed stratification (i.e. storing seed in moist soil subject to freeze/thaw cycles) greatly favored germination of forbs over grasses but the effect was not entirely consistent across all species within those groups. Viability of stored seed varied with species, length of time and storage conditions. The growing season prior to harvest had an effect, not only on numbers, but also on viability of seeds and seedlings produced. Variability of this nature ensures the long term survival of natural plant communities but makes it difficult to accurately predict the outcome of community development, whether it be natural or managed, given the vagaries inherent in the weather.

The disappointing results in the study cited by Redente et al. (1984) where efforts were made to establish diverse native plant communities from seed and five years later all plots were dominated by grasses were due, in part, to first year precipitation that favored grass establishment over forbs and shrubs. They reported greater seedling production and survival from grasses (seedlings from 10% of all grass seeds planted survived two years) compared to forbs (1%) and shrubs (2.5%) and suggest it was a result of poor first year moisture conditions coupled with competition from the grasses.

Species with C_3 (e.g. wheatgrass species) and C_4 (e.g. blue grama grass) metabolic pathways are common on the prairie so seed mixes used to establish diverse native plant communities will often contain seed from both groups. High temperatures favor establishment of C_4 grasses while cooler temperatures favor C_3 grasses. Therefore the timing of plantings, whether early spring or mid summer, for example, may influence the structure of the resulting plant community.

6.0 Summary

Land reclamation, whatever the end land use goal, is an effort to restore basic ecosystem functions and, arguably, energy capture is the primary one. Since energy capture is the sole purview of plants an understanding of plant succession is critically important. Succession and the factors affecting it will ultimately determine the success of reclamation of disturbed sites (Doerr et al. 1984). A variety of environmental factors can influence the rate, direction and eventual outcome of plant succession, whether natural or managed. And although they were discussed independently all or some will act and interact at different times and with different intensities. It seems an overwhelming task to incorporate all those conditions into reclamation planning and implementation but the effort must be made for successful restoration of damaged ecosystems.

7.0 General Research Objectives

The objective of this research was to evaluate atypical construction and reclamation procedures recently employed on a pipeline on native prairie in Alberta. The atypical construction techniques were implemented to facilitate ecosystem restoration not just equivalent capability as dictated by current Alberta legislation.

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II. SOD SALVAGE IN PIPELINE RECLAMATION: IMPLICATIONS FOR NATIVE PRAIRIE RESTORATION

1.0 Introduction

According to the World Wildlife Fund Canada (1988) only about 10% of the original fescue prairie and 25% of aspen parkland in Western Canada remains undisturbed and that portion is threatened by a variety of development pressures including agriculture, recreation and natural resource energy extraction. In Alberta in 1991 there were approximately 53,000 oil and gas wells and 4,500 km of pipeline within those two ecoregions (Kerr et al. 1993) and those numbers are growing. It has become a priority for regulatory agencies to conserve what remains of native fescue grasslands and thus stringent regulations for revegetation of public lands disturbed by industrial activities have been imposed. Many private landowners also demand that disturbed native prairie be restored to its original condition. In most cases this has resulted in industry using native grass seed mixes consisting primarily of late seral species for revegetation. Due to the lack of a consistent and adequately diverse supply of native plant material, coupled with a general lack of knowledge about native seed establishment requirements, most efforts at prairie restoration have been ineffective.

Most research on pipeline revegetation success has focused on agricultural crops. However, Reid (1977) studied the effects of pipeline installation on sandy soil grasslands in southern Alberta and found no significant differences in yield on older lines. Recently installed lines had a variable cover of crested wheatgrass (*Agropyron pectiniforme* R. & S.) if seeded and weedy species if not seeded. Disturbed sites with only natural revegetation resembled the adjacent undisturbed sites after several years. Hardy Associates (1978) Ltd. (1983) found decreases in productivity on native rangeland due to lack of topsoil replacement, topsoil and subsoil mixing, competition for weeds and gopher holes. Of all native rangeland sites studied, 81% had more than 10% reductions in live cover, height and/or weediness over the pipeline right-of-way (RoW). Naeth (1985) found pipeline construction severely altered botanical composition of the RoW. Following disturbance pioneer and introduced species dominated the RoW, particularly over the trench. On 26 year old sites species composition on the RoW was approaching that of the undisturbed prairie.

Very little research into methods of prairie restoration other than seeding has been undertaken. Sod salvage and replacement has been hypothesized as one viable reclamation technique. Sodding is considered feasible if several conditions are met (Kerr et al. 1993). These conditions include existing vegetation with a good cover of desirable, surface binding perennial species; soil sufficiently consolidated and rock free to be cut and moved; sufficient water to wet the sod prior to and after cutting; the area proving a favourable growth medium; and sufficient post sodding moisture.

The scientific literature on sod salvage is almost completely lacking. Revel (1993) monitored changes in a rough fescue (*Festuca campestris* Rydb.) community following sod transplanting. He reported a change in plant community structure away from dominance by deep-rooted bunch grasses (rough fescue) towards dominance by more shallow-rooted, rhizomatous grass species (bluegrasses (*Poa* sp. L.), wheatgrasses (*Agropyron* sp. Gaertn.) and forbs. Plant species richness was higher in the transplanted sod than in the control. Rough fescue survived the transplanting but a quantitative analysis was not conducted. Sodding had been successful in tall grass prairie restoration in Manitoba (Kerr et al. 1993). Although 50 to 75% of the species survived, including many deep rooted plants, weeds were a problem and it was very expensive. Successful sodding was also achieved in Colstrip, Montana after coal mining (Bunin et al. 1982).

2.0 Research Objectives

1. To evaluate the effects of native prairie sod salvage and replacement on the native plant community developing on the pipeline RoW.
2. To determine the survival rate of sod salvaged native rough fescue grass plants on the pipeline RoW.

3. To compare the developing plant communities on seeded and sodded treatments and the undisturbed native prairie.

3.0 Materials and Methods

3.1 Site Descriptions

In 1996 a large diameter (61 cm) pipeline traversing 435 km of east central and southeastern Alberta was constructed by Express Pipeline. Two research sites were randomly selected along the RoW with the criterion that rough fescue made up a significant portion of the plant community.

The Hardisty site is located in a public grazing reserve approximately 22 km south of Hardisty, Alberta, within the Groveland Subregion of the Aspen Parkland (Strong and Leggat 1981). This subregion is described as a tension zone between Fescue and Mixed Grass Ecoregions and the Aspen Subregion. Aspen (*Populus tremuloides* Michx.) clones, which cover about 15% of the area, and shrub communities share the moister north facing slopes and ravines. Typical shrubs include saskatoon (*Amelanchier alnifolia* Nutt.), wild rose (*Rosa* species L.), buckbrush (*Symphoricarpos* species Duhamel) and silverberry (*Elaeagnus commutata* Bernh. ex Rydb.). Native fescue grasslands dominated by rough fescue (*Festuca hallii* (Vasey) Piper), Idaho fescue (*Festuca idahoensis* Elmer), june grass (*Koeleria macrantha* (Ledeb.) J.A. Schultes f.), spear and needle grasses (*Stipa* species L.) and numerous forbs occur on the uncultivated portion of the region. Some important introduced species on the grasslands include smooth brome (*Bromus inermis* Leyss.), bluegrasses (*Poa* species L.) and dandelion (*Taraxacum officinale* Weber).

The Aspen Parkland receives an annual average of 450 mm of precipitation of which 40% falls as snow (Strong and Leggat 1981). The mean May to September precipitation is 300 mm distributed evenly throughout the growing season. Typical soils in the region are Dark Brown, Dark Gray and Black Chernozems. Soil at the site is an Orthic or Rego Dark Brown Chernozem of the Hughendon soil unit (Leskiw et al. 1993) (Tables A.1, A.5, A.6).

The Manyberries site is approximately 40 km south of Medicine Hat, Alberta in the southeastern portion of the Mixed Grass Ecoregion on the western edge of the Cypress Hills. Compared to most of the ecoregion the site is cool and moist due to its elevation. Except for the lack of aspen clones and fewer shrub communities, native vegetation is similar to the Hardisty site. This region receives 200 to 290 mm of precipitation annually with the majority of growing season rainfall in June. The modal soil for the ecoregion is a Dark Brown Chernozem. Soil at this site is an Orthic Dark Brown Chernozem from the Purescape soil unit (Leskiw et al. 1993) (Tables A.2, A.7, A.8).

3.2 Experimental Design and Treatments

The experimental design is a randomized complete block with three treatments: seeded, sodded and undisturbed native prairie. The Hardisty site consists of three blocks each 45 m long; the Manyberries site has four 35 m long blocks.

The RoW is subject to different disturbances during pipeline construction so the treatments were divided laterally into spoil, work and trench zones. The RoW is 20 m wide, centered over the buried pipe. The trench zone is 1.5 m wide and 2 m deep. Each of the spoil and work zones is 9.25 m wide. The spoil zone is subject to the least overall disturbance; subsoil material from the trench is piled there and following pipe installation is graded back into the trench. Topsoil is stored at the outside of the work zone and the majority of traffic is restricted to the area between the topsoil pile and the trench. The transplanted sod strip is approximately 6 m wide, centered over the trench. Topsoil was stripped from the seeded treatments across the entire 20 m RoW at Hardisty but at Manyberries about 4 m of unstripped prairie remained on either side of the RoW. At Manyberries wheat straw was crimped into the seeded treatment when it was seeded. Due to the nature of pipeline construction neither blocks nor zones could be randomly located.

The sod was removed the second week of September and replaced the second week of November when vegetation was dormant. One meter square pieces of sod approximately 10 to 15 cm deep were cut with a backhoe fitted with a concrete cutter. Sod pieces were stored on pallets with a layer of white Mirafee filter cloth between pieces of sod; the stack of sods was eventually covered with filter cloth. This filter cloth was chosen for its superior reflective properties to minimize heating of the sod. The sod was replaced with a backhoe and labourers. The sites were seeded (Tables B.88, B.89) in the second week of June 1997.

3.3 Vegetation Measurements

Plant species density is useful in describing the relative plentifulness or scarcity of a species. Daubenmire (1968) describes density as key to understanding population dynamics. Cain and de Oliveira Castro (1959) state it is useful in describing the nature of change that may be occurring in the community. Plant density is an important consideration in land reclamation as reclamation certificates are not issued unless density on revegetated wellsite disturbances on grasslands in Alberta is greater than or equal to 80% of control vegetation (Alberta Environmental Protection 1995).

Percent ground cover of live vegetation is analogous to basal area which is the cross-sectional area of individual plants taken at or near the ground surface (Daubenmire 1968). Basal area is recommended over canopy measurements in grassland studies because of the potential effects weather or grazing may have on the canopy (Cain and de Oliveira Castro 1959). The sum of individual plant basal areas yields total area covered by plants and this, combined with other ground cover measurements are important in land reclamation and revegetation because erosion prevention is a key goal. The Reclamation criteria for wellsites (Alberta Environmental Protection 1995) require that the number and size of bare areas should not exceed original or control vegetation.

Species richness, the number of species per unit area, can be used synonymously with diversity (Walker 1988, Tilman et al. 1996) and according to some is indicative of ecosystem stability. For example, Tilman and Downing (1994) states that one of the ecological tenets justifying conservation of biodiversity is that diversity begets stability. Other researchers do not support this view, among them Kent and Coker (1992) who state that there is no clear relationship between high diversity or species richness and ecosystem/community stability. Walker (1988), among others, suggests diversity is a function of disturbance or instability. For this research species richness is used as another measure of the similarity of plant communities on and off the pipeline RoW.

Blocks of RoW zones were each sampled at 10 randomly located 0.1 m^2 quadrats. There were thus 30 quadrats per zone of each treatment at Hardisty in each year and 40 at Manyberries; undisturbed prairie was sampled at both sites in 30 randomly located quadrats approximately 10 m from the RoW in each of the study years. Visual vegetation assessments were made in each quadrat for percent species composition and percent ground cover (live vegetation, litter, bare ground, rocks, moss, lichen). Little club moss (*Selaginella densa* Rydb.) was included in the moss category. Plant species density was measured for plants rooted in the quadrat.

3.4 Soil Measurements

Soil surface density and moisture data were obtained with a Campbell Pacific Nuclear model MC-1 moisture density probe (Chanasyk and Naeth 1988). Five measurements were made in each replicate of each zone. Penetration resistance was measured at 10 locations in each replicate of each zone at 0, 2.5, 5, 7.5, 10, 12.5, 15 and 20 cm depths with a 30° cone penetrometer. Three soil samples from 0 to 5 cm per replicate per zone on the RoW were composited and taken for laboratory analysis of pH, electrical conductivity (EC), total carbon (C) and particle size distribution (sand, silt, clay). Soil samples for the undisturbed prairie were similarly collected for each depth interval of 0 to 5, 5 to 15, 15 to 30 and 30 to 45 cm but only one randomly selected composited sample was analyzed. Soils data are presented for the readers interest in Appendix A.

Laboratory samples were air dried and ground to pass a 2 mm sieve. Soil pH was determined with an Acumet model 630 pH meter in a 1:2 soil:water solution. EC was measured with a Yellow Springs Instrument Co. model 31 conductivity bridge in a 1:2 soil:water paste. A Leco Carbon Analyser was used for total carbon determination.

Particle size distribution was measured by the hydrometer method. These procedures are presented in Carter (1993).

3.5 Statistical Analyses

Statistical analyses were completed with the GLM procedure in SAS (SAS Institute Inc. 1988). Analysis of variance (ANOVA) was performed on total plant density, species richness, live vegetation ground cover (excluding *Selaginella densa*) and bare ground. To enable statistical comparisons among individual zones, treatments and the undisturbed prairie, two statistical models were used. One model set the undisturbed prairie as a zone, the other set it as a treatment. The first model facilitates comparison of the individual zones to each other and to the control over the two year study period. The second model facilitates examination and comparisons between treatments and the control over time. The variables examined were year, site, treatment, zone and year by treatment, year by zone and year by treatment by zone interactions. The model main effects were tested first by the F ratio and secondly by the Bonferroni technique. The Bonferroni method holds the experimental Type I error rate to 0.05. T-tests were performed between the means of individual components of the year by treatment by zone interaction terms and were deemed significant when $p > T \leq 0.05$. The statistical model used was:

$$Y_{ijkl} = \mu + \alpha_i + \beta_j + \gamma_k + \chi_l + (\alpha\gamma)_{ik} + (\alpha\chi)_{il} + (\alpha\gamma\chi)_{ikl} + \varepsilon_{ijkl}$$

where: μ = grand mean.

α_l = effect of year.

β_j = effect of site.

γ_k = effect of treatment.

χ_l = effect of zone.

$(\alpha\gamma)_{ik}$ = year by treatment interaction.

$(\alpha\chi)_{il}$ = year by zone interaction.

$(\alpha\gamma\chi)_{ikl}$ = year by treatment by zone interaction.

ε_{ijkl} = error term.

Plant species were grouped to make meaningful comparisons across sites because many species with similar ecological characteristics (e.g. introduced annuals, native bunch grasses) occurred only at one site but were abundant overall. Eleven groups were established: rough fescue, other native bunch grasses, native rhizomatous grasses, native forb increasers (*Artemisia* sp), native forbs, sedges, introduced grasses, introduced bluegrasses, introduced annuals, introduced perennials and shrubs.

A separate ANOVA was performed on rough fescue density and ground cover data from the sodded trench and undisturbed prairie. The variables examined were year, site, zone and year by zone, site by zone and year by site by zone interactions with site considered a fixed variable.

Mean plant species density from the trench in 1997 and 1998 and the undisturbed prairie were compared using the Spatz similarity index (Mueller-Dombois and Ellenberg 1974) as a measure of relative resemblance of the zone to the control at the end of the study and over the 2 year period. The Spatz similarity index is calculated by a weighted average of abundance values of species common to both communities, multiplied by the % abundance values of common species from the total abundance values of all species. In this case mean species density is the abundance value.

4.0 Results and Discussion

Although some of the measurement differences between treatments and zones may seem insignificant, either biologically or statistically, the results are expressed for the measured variable per 0.01 m^2, the area of one quadrat. A different perspective might be gained by considering some of the small differences on a larger scale. This principle applies equally to small temporal changes reported here.

4.1 Plant Density

Overall plant density and treatment densities increased marginally from 1997 to 1998 (Tables 2.1, B.1, B.5 to B.11, B.19 to B.25). Hardisty had significantly higher plant densities than Manyberries. The undisturbed prairie had significantly higher densities than the sodded or seeded treatments, with sodded being significantly higher than seeded in both years of the study. Zone of RoW also affected density with higher values on the spoil than either the trench or the work zones.

The small increases in plant density on the RoW between 1997 and 1998 are mainly due to the establishment of relatively large numbers of native forb increasers and introduced annuals (weeds), with some increases in native bunch grasses (Table 2.2). The small decreases in density on both the sodded and seeded treatments is due, primarily, to the disappearance of some sedges and some forbs.

4.2 Species Richness

Overall species richness increased significantly over the two year study period (Tables 2.3, B.2). Species richness at Hardisty was significantly greater than at Manyberries. The undisturbed prairie had the highest species richness, followed by the sodded then seeded treatments. With time, species richness on the seeded treatment increased significantly but only marginally on the sodded treatment. All RoW zones had significantly fewer species than the undisturbed prairie. Over time species richness on all zones except the sodded trench increased; significantly so on the seeded trench and seeded work treatments (Table B.2).

4.3 Ground Cover

Live vegetation ground cover increased significantly over the two year study period (Tables 2.4, B.3, B.12 to B.18, B.26 to B.32). Live vegetation on the sodded treatment was significantly greater than on the seeded treatment in both years and by 1998 was not significantly different than the undisturbed control. On average, over both years, all RoW zones had significantly less ground cover than the undisturbed prairie.

Changes in ground cover over time are due to the growth of existing plants and, to a lesser degree, establishment of new plants, primarily annual weeds. Sod salvaging resulted in less ground cover disturbance initially which lead to its more rapid recovery to predisturbance levels. The spoil zone is subject to the least initial disturbance that influenced its more rapid return to predisturbance conditions.

Bare ground decreased significantly from 1997 to 1998 overall but the change was not consistent across treatments and zones (Tables 2.5, B.4, B.33, B.34). Bare ground was significantly lower on the sodded versus seeded treatments and both had significantly more than undisturbed prairie. Bare ground on both treatments declined significantly with time but the change was greatest on the seeded ones. This may be due to straw crimping at the Manyberries site in 1997 where litter ground cover was considerably higher than Hardisty in 1998 (Table B.34).

4.4 Rough Fescue

At both sites rough fescue density declined from 1997 to 1998 (Table 2.6). At Hardisty the transplanted sod supported significantly fewer fescue plants than the undisturbed prairie right from the beginning of the study and by 1998 it completely disappeared. Despite the continuous decline in fescue density at Manyberries, by 1998 it was not significantly different from the undisturbed prairie. Ground cover of fescue was also significantly higher at Manyberries than Hardisty (Table 2.7) and lower on the trench than in the undisturbed prairie in 1997 and 1998.

Differences in plant communities at the sites may have contributed to differences in success of the transplanted fescue. The Hardisty plant community was more degraded than Manyberries and would be in an earlier successional state. It supports fewer native bunch grasses and more forbs, weeds and introduced grasses, especially the very aggressive bluegrasses which expanded rapidly. Despite the fact that there was no statistically significant difference in rough fescue density in the undisturbed prairie at either site, at Hardisty rough fescue occupied only half as much area as at Manyberries. On average, fescue plants at Hardisty were smaller than those at Manyberries which may have contributed to the decline in ground cover by rough fescue at Hardisty (Table 2.7).

4.5 Similarity Comparisons

At both sites, individually and overall, the sodded trench more closely resembled the undisturbed prairie than did the seeded trench (Table 2.8). Overall similarity of the seeded trench to the undisturbed prairie increased from 1997 to 1998 while the opposite was true for the sodded trench. The process of change in the plant community initiated by the disturbance resulting from transplanting appears to have not been completed. At Hardisty both seeded and sodded trench zones declined in similarity to the undisturbed prairie over the two years whereas at Manyberries similarity of both those zones increased. These results reflect the differences in the plant communities at the two sites previously discussed. Soils were not affected by disturbance sufficiently to have caused changes in the vegetation (Tables B.5 to B.8).

4.6 Similarities to Previous Research and Practical Applications

The results of this research mirror those of Revel (1993) and follow closely the trends reported in many studies of disturbed grassland plant community dynamics in North America. Disturbance caused the community to shift to an earlier seral state wherein some late seral individuals were displaced by individuals from more disturbance adapted species. The resulting plant community was mixed, in that the entire spectrum of seral stages was represented. These results are in close agreement to the idea presented by Grime (1979) that many species found in grassland plant communities occupy more than one position in the successional hierarchy.

Salvaging native prairie sod prior to construction, although a significant disturbance in itself, conserved a good representative sample of the pre-disturbance plant community. Propagules, primarily seed, from many of the species in the transplanted sod are not currently available commercially and may never be. Furthermore, establishment requirements of many of those species are not well understood. Although the expense of carefully salvaging, storing and transplanting native prairie sod may prohibit its use on very large scale reclamation projects it may be useful when disturbance to highly sensitive areas cannot be avoided or when immediate post-disturbance ground cover is required. Sod salvage may also be useful on a small scale where, rather than salvaging large areas, individual sods could be salvaged and replaced intermittently. This could occur, for example every few hundred meters along a pipeline right-of-way or a few sods could be used on a wellsite. These individual sods would act primarily as a source of otherwise unavailable propagules thereby promoting restoration of the disturbed areas.

Site selection is a key consideration in sod salvaging efforts. The presence of aggressive introduced plants decreases the chances of successful sod transplanting in proportion to their abundance in the transplanted and/or surrounding vegetation.

5.0 Conclusions

1. Rough fescue sod can be successfully transplanted.
2. Sod salvage and replacement resulted in the establishment and/or increased abundance of early seral stage plant species.
3. The magnitude of that effect changed with the nature of the original plant community.
4. Native prairie sod salvage is an effective reclamation technique.

6.0 References

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Table 2.1. Plant density (number of plants 0.1 m^{-2}) at the sod salvage research sites in 1997 and 1998.

Category		Mean	SD	n
Year	1997	22.7 a	20.3	540
	1998	23.6 a	18.8	540
Site	Hardisty	28.5 a	21.6	480
	Manyberries	18.8 b	17.8	600
Treatment	Undisturbed prairie	50.7 a	22.4	150
	Seeded	10.9 c	11.0	420
	Sodded	19.5 b	15.4	420
Right-of-Way Zone	Undisturbed prairie	50.7 a	22.4	150
	Spoil	18.9 b	16.8	280
	Trench	13.4 c	10.8	280
	Work	13.4 c	13.2	280
Year and Treatment	Undisturbed prairie	50.7 a	22.4	150
	1997 Seeded	10.4 c	12.5	210
	1997 Sodded	18.9 b	15.8	210
	1998 Seeded	11.4 c	9.1	210
	1998 Sodded	20.1 b	15.0	210

SD: standard deviation

Means with the same letter within a category are not significantly different at $p \leq 0.05$

Table 2.2. Grouped species density from right-of-way zones on the sod salvage research sites in 1997 and 1998.

Treatment Zone	Group	1997 Mean	1997 SD	1998 Mean	1998 SD
Seeded spoil	rough fescue	0.6	2.2	0.3	0.7
	native bunch grasses	3.8	6.1	4.9	4.3
	native rhizomatous grasses	2.2	1.7	1.8	2.0
	introduced grasses	0.0	0.0	0.1	0.3
	sedges	2.3	5.9	1.3	3.3
	bluegrasses	0.8	2.9	0.4	1.8
	native forb increasers	0.8	2.5	0.7	1.7
	native forbs	3.0	6.4	1.9	3.0
	introduced annuals	0.4	0.8	2.5	6.8
	introduced perennials	0.2	0.4	0.4	0.9
	shrubs	0.1	0.6	0.1	0.3
Seeded trench	rough fescue	0.2	1.0	0.2	0.6
	native bunch grasses	3.8	3.5	4.3	3.3
	native rhizotamous grasses	1.1	1.3	1.6	1.9
	introduced grasses	0.0	0.1	0.1	1.0
	sedges	0.2	0.5	0.1	0.5
	bluegrasses	0.1	0.4	0.1	0.4
	native forb increasers	0.0	0.1	0.2	0.7
	native forbs	0.5	0.8	0.4	1.1
	introduced annuals	0.2	0.6	2.4	6.7
	introduced perennials	0.1	0.4	0.4	1.0
	shrubs	0.1	0.4	0.2	0.5
Seeded work	rough fescue	0.8	3.3	0.7	2.2
	native bunch grasses	1.7	2,5	3.7	4.3
	native rhizotamous grasses	1.0	1.2	1.1	1.8
	introduced grasses	0.0	0.1	0.0	0,2
	sedges	1.1	3.7	1.0	3.3
	bluegrasses	0.1	0.4	0.3	1.2
	native forb increasers	0.3	1.4	0.5	1.3
	native forbs	1.2	2.6	1.3	2.0
	introduced annuals	0.2	0.5	0.6	1.2
	introduced perennials	0.1	0.4	0.2	0.6
	shrubs	0.1	0.3	0.3	0.8

Table 2.2. Grouped species density from right-of-way zones on the sod salvage research sites in 1997 and 1998. (cont'd)

Treatment		1997		1998	
Zone	Group	Mean	SD	Mean	SD
Sodded spoil	rough fescue	2.7	5.1	1.3	2.7
	native bunch grasses	2.8	4.1	3.0	3.3
	native rhizotamous grasses	1.2	3.5	1.4	2.8
	introduced grasses	0.3	1.0	0.3	1.2
	sedges	7.3	13.5	3.5	6.7
	bluegrasses	1.5	3.4	1.5	3.5
	native forb increasers	1.6	3.1	2.7	5.4
	native forbs	4.2	5.5	4.3	5.1
	introduced annuals	0.1	0.4	3.2	6.7
	introduced perennials	0.1	0.4	0.9	3.0
	shrubs	0.6	1.3	0.4	1.3
Sodded trench	rough fescue	2.9	4.0	1.8	3.6
	native bunch grasses	3.0	2.5	3.0	2.7
	native rhizotamous grasses	0.4	0.9	0.4	1.1
	introduced grasses	0.0	0.3	0.1	0.5
	sedges	4.2	4.8	4.6	7.8
	bluegrasses	1.6	3.6	2.1	4.5
	native forb increasers	0.7	1.3	1.8	4.2
	native forbs	2.0	3.1	1.9	2.8
	introduced annuals	0.2	0.6	3.8	7.3
	introduced perennials	0.2	0.5	1.1	6.5
	shrubs	0.2	0.7	0.2	0,7
Sodded work	rough fescue	1.6	3.3	1.0	1.9
	native bunch grasses	2.2	2.5	2.3	2.0
	native rhizotamous grasses	1.3	2.3	1.1	2.3
	introduced grasses	0.0	0.2	0.1	0.2
	sedges	5.8	9.9	3.8	7.6
	bluegrasses	2.6	6.8	2.2	5.3
	native forb increasers	0.9	1.9	1.4	2.8
	native forbs	3.2	4.5	3.5	4.2
	introduced annuals	0.2	0.4	0.9	2.2
	introduced perennials	0.2	0.5	0.2	1.0
	shrubs	0.6	2.0	0.5	1.5

n = 70
SD: standard deviation

Table 2.3. Species richness (number of species $0.1m^{-2}$) at the sod salvage research sites in 1997 and 1998.

Category		Mean	SD	n
Year	1997	5.0 a	2.6	540
	1998	5.3 b	2.4	540
Site	Hardisty	6.0 a	2.1	480
	Manyberries	4.5 b	2.6	600
Treatment	Undisturbed prairie	6.8 a	2.1	150
	Seeded	4.2 c	2.4	420
	Sodded	5.1 b	2.4	420
Right-of-Way Zone	Undisturbed prairie	6.8 a	2.1	150
	Spoil	5.4 b	2.5	280
	Trench	4.2 c	2.1	280
	Work	4.4 c	2.5	280
Treatment	1997 Undisturbed prairie	6.9 a	2.2	90
	1997 Seeded	3.9 d	2.5	210
	1997 Sodded	5.0 b	2.4	210
	1998 Undisturbed prairie	6.7 a	2.1	60
	1998 Seeded	4.5 c	2.3	210
	1998 Sodded	5.2 b	2.4	210

SD: standard deviation

Means with the same letter within a category are not significantly different at $p \leq 0.05$

Table 2.4. Live vegetation ground cover (%) at the sod salvage research sites in 1997 and 1998.

Category		Mean	SD	n
Year	1997	3.6 b	5.5	535
	1998	7.5 a	4.8	536
Site	Hardisty	5.5 a	5.2	473
	Manyberries	5.5 a	5.7	598
Treatment	Undisturbed prairie	8.8 a	5.0	150
	Seeded	3.9 c	4.8	417
	Sodded	5.3 b	5.7	414
Right-of-Way Zone	Undisturbed prairie	8.8 a	5.0	150
	Spoil	5.1 b	5.2	273
	Trench	4.5 b	5.4	278
	Work	4.2 b	5.2	280
Treatment	1997 Undisturbed prairie	8.9 a	2.3	90
	1997 Seeded	1.3 e	2.7	209
	1997 Sodded	2.8 d	2.2	206
	1998 Undisturbed prairie	8.6 ab	2.2	60
	1998 Seeded	6.6 c	2.5	208
	1998 Sodded	7.8 b	2.8	208

SD: standard deviation

Means with the same letter within a category are not significantly different at $p \leq 0.05$

Table 2.5. Bare ground (%) at the sod salvage research sites in 1997 and 1998.

Category		Mean	SD	n
Year	1997	71.1 a	40.0	535
	1998	64.7 b	36.0	536
Site	Hardisty	68.3 a	37.8	473
	Manyberries	67.7 a	38.5	598
Treatment	Undisturbed prairie	6.1 c	17.9	150
	Seeded	87.2 a	18.7	417
	Sodded	84.3 b	19.2	414
Right-of-Way Zone	Undisturbed prairie	6.1 c	17.9	150
	Spoil	85.3 ab	18.5	273
	Trench	81.6 b	23.3	278
	Work	90.4 a	12.9	280
Treatment	1997 Undisturbed prairie	1.4 f	4.5	90
	1997 Seeded	96.0 a	5.4	209
	1997 Sodded	86.6 b	20.4	206
	1998 Undisturbed prairie	10.9 e	24.1	60
	1998 Seeded	78.5 d	22.8	208
	1998 Sodded	82.1 c	17.9	208

SD: standard deviation

Means with the same letter within a category are not significantly different at $p \leq 0.05$

Table 2.6. Rough fescue density (number of plants of 0.1m^{-2}) at the sod salvage research sites in 1997 and 1998.

Category		Mean	SD	n
Year	1997	3.5 a	4.3	130
	1998	2.9 a	4.2	130
Site	Hardisty	1.8 b	4.6	120
	Manyberries	4.4 a	3.3	140
Right-of-Way Zone	Undisturbed prairie	4.2 a	4.5	120
	Trench	2.4 b	3.9	140
Zone and Year	Hardisty undisturbed prairie	3.4 a	4.0	30
	1997 Hardisty trench	0.5 b	1.0	30
	1998 Hardisty trench	0.0 b	0.0	30
	Manyberries undisturbed prairie	4.9 a	4.9	30
	1997 Manyberries trench	4.7 a	4.5	40
	1998 Manyberries trench	3.2 a	4.4	40

SD: standard deviation
Means with the same letter within a category are not significantly different at $p \leq 0.05$

Table 2.7. Ground cover (%) of rough fescue at the sod salvage research sites in 1997 and 1998.

Category		Mean	SD	n
Year	1997	0.8 a	1.5	130
	1998	1.0 a	1.5	130
Site	Hardisty	0.5 a	0.7	120
	Manyberries	1.2 b	1.9	140
Right-of-Way Zone	Undisturbed prairie	1.4 a	1.8	120
	Trench	0.4 b	0.9	140
Zone and Year	Hardisty undisturbed prairie	1.0 bc	0.8	30
	1997 Hardisty trench	0.02 d	0.04	30
	1998 Hardisty trench	0.0 d	0.0	30
	Manyberries undisturbed prairie	1.9 a	2.4	30
	1997 Manyberries trench	0.4 c	0.9	40
	1998 Manyberries trench	1.0 b	1.2	40

SD: standard deviation
Means with the same letter within a category are not significantly different at $p \leq 0.05$

Table 2.8. Spatz similarity indices between zones and the undisturbed prairie from the sod salvage research sites in 1997 and 1998.

Zone compared	1997	1998
Overall seeded trench	10.48	11.96
Overall sodded trench	18.67	16.24
Hardisty seeded trench	11.89	11.49
Hardisty sodded trench	20.11	15.63
Manyberries seeded trench	8.04	12.78
Manyberries sodded trench	16.28	17.22

III. MINIMAL DISTURBANCE PIPELINE RECLAMATION: IMPLICATIONS FOR NATIVE PRAIRIE RESTORATION

1.0 Introduction

World Wildlife Fund Canada (1988) estimates that 15% of the Dry Mixed-Grass Prairie Ecoregion has less than 10% cover of native prairie remaining; 26% has 10 to 50% and 59% has more than 50% of its original vegetation. Much of the ecoregion has been broken by the plow and is subject to extensive pressure from agriculture, recreation and natural resource energy extraction. In Alberta in 1991 there were approximately 41,000 oil and gas wells and 2,600 km of pipeline within the ecoregion (Kerr et al. 1993) and those numbers are growing. It has, therefore, become a priority for regulatory agencies in Alberta to conserve the remaining native prairie grasslands and stringent regulations for revegetation of public lands disturbed by industrial activities have been imposed. Many private landowners also demand that disturbed native prairie be restored to its original condition. In most cases this has resulted in industry using native grass revegetation mixes consisting of late seral species. Due to lack of a consistent and adequately diverse supply of native plant material coupled with a general lack of knowledge about native seed establishment requirements, most efforts at prairie restoration have been ineffective.

Pipeline construction on native prairie typically follows the same general sequence of activities. First, topsoil and sod are stripped and bladed to the side of the right-of-way (RoW). The second soil horizon is bladed to the side adjacent to the topsoil/sod. Trenching and pipe installation are then carried out on the subsoil. After the pipe is buried the stored soil is bladed back onto the RoW, recontoured and seeded.

Most research on pipeline revegetation success has focused on agricultural crops. However, Reid (1977) studied the effects of pipeline installation on sandy soil grasslands in southern Alberta and found no significant differences in yield on older lines. Recently installed lines had a variable cover of crested wheatgrass (*Agropyron pectiniforme* R. & S.) if seeded and weedy species if not seeded. Disturbed sites with only natural revegetation resembled the adjacent undisturbed sites after several years. Hardy Associates (1978) Ltd. (1983) found decreases in productivity on native rangeland due to lack of topsoil replacement, topsoil and subsoil mixing, weed competition and gopher holes. Of the sites studied, 81% had more than 10% reductions in live cover, height and/or weediness over the pipeline right-of-way (RoW). Naeth (1985) found pipeline construction severely altered botanical composition of the RoW. Following disturbance pioneer and introduced species dominated the RoW, particularly over the trench. On 26 year old sites species composition on RoW was approaching the undisturbed prairie.

Very little research into methods of prairie restoration other than seeding has been undertaken. Minimum disturbance through not stripping the RoW has been hypothesized as a reclamation technique to facilitate restoration. In this no-strip technique, trenching, pipe installation and burial are conducted directly on the prairie surface without stripping any soil. The resulting initial disturbance is much smaller than if the RoW is stripped over its entire width. Since native prairie topsoil contains reserves of viable native seed this should also enhance restoration efforts through increased availability of plant propagules. However, this influence on revegetation in a natural setting is not well documented and scientific research on its effectiveness is lacking.

In a recent study on small diameter (15 cm) pipelines in southern Alberta, Adams et al. (1996) supported no-strip pipeline construction. Three years after construction the plant community on the no-strip area more closely resembled undisturbed prairie than did the adjacent stripped treatment. They reported more disturbance to native prairie from stripping but no-strip adversely affected surface soil chemical properties. Sodium adsorption ratio (SAR) was elevated from trenching through sodic subsoil, but by the third year SAR values declined and did not appear to negatively affect the vegetation.

2.0 Research Objectives

1. To evaluate plant community structure and diversity with no-strip and conventional right-of-way stripping pipeline construction techniques.

2. To compare the above treatments to the undisturbed prairie.

3. To evaluate the contribution of the seedbank on the RoW to the revegetation process.

3.0 Materials and Methods

3.1 Site Descriptions

In 1996 a large diameter (61 cm) pipeline traversing 435 km of east central and southeastern Alberta was constructed by Express Pipeline. Two research sites, approximately 21 km apart, were randomly selected along the RoW where no-strip construction was used adjacent to areas where conventional topsoil stripping was employed.

Both research sites are located near Jenner, Alberta in the Dry Mixed-Grass Ecoregion. This ecoregion is the driest in Alberta, with precipitation averaging 210 mm in May through August and 340 mm annually (Strong and Leggat 1981). Summer temperatures are the warmest in Alberta averaging 16.2° C with mean monthly maximums from 23 to 28 °C. Extreme highs often exceed 30 °C. Potential evapotranspiration deficits exceed 100 mm per month, excluding the effect of persistent winds common to the region.

Native plant communities are dominated by needle grasses (*Stipa* species L.), blue grama grass (*Bouteloua gracilis* (HBK) Lag.), june grass (*Koeleria macrantha* (Ledeb.) J.A. Schultes f.), little club moss (*Selaginella densa* Beauv.), fringed sage (*Artemisia frigida* Willd.), moss phlox (*Phlox hoodii* Richards.) and thread-leaved sedge (*Carex filifolia* Nutt.) (Strong and Leggat 1981).

Shallow soil profile development also reflects the lack of moisture. Topsoil depths are typically less than 10 cm and often less than 5 cm. Rego soils are common. Modal soils in the ecoregion are Brown Chernozems with significant occurrences of Solonetzes. Soil at the northern site is a sandy loam to fine sandy loam textured Orthic Brown Chernozem from the Bingville soil unit; the southern site has a fine sandy loam to loam textured Brown Solod from the Halliday soil unit (Leskiw et al. 1993) (Tables A.3 and A.4).

3.2 Experimental Design and Treatments

Following soil replacement after trenching, half of each area was seeded and the other halves were left to recover naturally. There are, therefore, four treatments: strip/seed, strip/no-seed, no-strip/seed and no-strip/no-seed. The sites were seeded (Tables B.86, B.87) in the second week of June, 1997.

The experimental design is a complete randomized block. Both sites consist of three blocks each 20 m long of each of the four randomly located treatments. Different areas of the RoW are subject to different degrees of disturbance during pipeline construction so the treatments were divided laterally into three (spoil, work and trench) RoW zones. Due to the nature of pipeline construction neither blocks nor zones could be randomized.

The RoW is 20 m wide, centered over the buried pipe. The trench zone is 1.5 m wide and 2 m deep. Each of the spoil and work zones is 9.25 m wide. The spoil zone is subject to the least disturbance; subsoil material from the trench is piled there and after pipe installation is graded back into the trench. Due to the volume of soil displaced by installation of the pipe a strip of subsoil about 5 m wide was left on the prairie surface along the RoW center in no-strip treatments. Topsoil is stored outside the work zone and the majority of traffic is restricted to the area between topsoil pile and trench. On the stripped treatments topsoil was stripped across the entire RoW at the northern site but at the southern site about 4 m of unstripped prairie remained on the spoil side of the RoW. This results in the trench zone being the most consistently and comparably disturbed area.

3.3 Vegetation Measurements

Plant species density is useful in describing the relative plentifulness or scarcity of a species. Daubenmire (1968) describes density as key to understanding population dynamics. Cain and de Oliveira Castro (1959) state it is useful in describing the nature of change that may be occurring in the community. Plant density is an important consideration in land reclamation as reclamation certificates are not issued unless density on revegetated wellsite disturbances on grasslands in Alberta is greater than or equal to 80% of control vegetation (Alberta Environmental Protection 1995).

Percent ground cover of live vegetation is analogous to basal area which is the cross-sectional area of individual plants taken at or near the ground surface (Daubenmire 1968). Basal area is recommended over canopy measurements in grassland studies because of the potential effects weather or grazing may have on the canopy (Cain and de Oliveira Castro 1959). The sum of individual plant basal areas yields total area covered by plants and this, combined with other ground cover measurements are important in land reclamation and revegetation because erosion prevention is a key goal. The Reclamation criteria for wellsites (Alberta Environmental Protection 1995) require that the number and size of bare areas should not exceed original or control vegetation.

Species richness, the number of species per unit area, can be used synonymously with diversity (Walker 1988, Tilman et al. 1996) and according to some is indicative of ecosystem stability. For example, Tilman and Downing (1994) states that one of the ecological tenets justifying conservation of biodiversity is that diversity begets stability. Other researchers do not support this view, among them Kent and Coker (1992) who state that there is no clear relationship between high diversity or species richness and ecosystem/community stability. Walker (1988), among others, suggests diversity is a function of disturbance or instability. For this research species richness is used as another measure of the similarity of plant communities on and off the pipeline RoW.

Blocks of RoW zones were each sampled at 10 randomly located 0.1 m^2 quadrats. There were thus 30 quadrats per zone in each treatment; undisturbed prairie was sampled at both sites in 30 randomly located quadrats approximately 10 m from the RoW in each of the study years. Visual vegetation assessments were made in each quadrat for percent species composition and percent ground cover (live vegetation, litter, bare ground, rocks, moss, lichen). Little club moss (*Selaginella densa* Rydb.) was included in the moss category. Plant species density was measured for plants rooted in the quadrat.

3.4 Seedbank Analyses

Thirty random 2.7 cm diameter by 2.5 cm deep (14.5 cc) samples of topsoil were composited from each replicate of the trench zone in all treatments at both sites after the soil was replaced and prior to seeding. Those samples were grown out over a 37 day period in a growth chamber at an accredited seed lab using standard seed germination testing methods. The growth chamber was divided into top, middle and bottom levels and soil from each replicate was divided equally into three sub samples. One of each was grown out on each level. Newly emerged seedlings were counted on days 9, 16, 23, 30 and 37.

3.5 Soil Measurements

Soil surface density and moisture data were obtained with a Campbell Pacific Nuclear model MC-1 moisture density probe (Chanasyk and Naeth 1988). Five measurements were made in each replicate of each zone. Penetration resistance was measured at 10 locations in each replicate of each zone at 0, 2.5, 5, 7.5, 10, 12.5, 15 and 20 cm depths with a 30° cone penetrometer. Three soil samples from 0 to 5 cm per replicate per zone on the RoW were composited and taken for laboratory analysis of pH, electrical conductivity (EC), total carbon (C) and particle size distribution (sand, silt, clay). Soil samples for the undisturbed prairie were similarly collected for each depth interval of 0 to 5, 5 to 15, 15 to 30 and 30 to 45 cm but only one randomly selected composited sample was analyzed. Soils data are presented, for the readers interest, in Appendix A.

Laboratory samples were air dried and ground to pass a 2 mm sieve. Soil pH was determined with an Acumet model 630 pH meter in a 1:2 soil:water solution. EC was measured with a Yellow Springs Instrument Co. model 31 conductivity bridge in a 1:2 soil:water paste. A Leco Carbon Analyser was used for total carbon determination. Particle size distribution was measured by the hydrometer method. These procedures are presented in Carter (1993).

3.6 Statistical Analyses

The GLM procedure in SAS (SAS Institute Inc. 1988) was used to perform analysis of variance (ANOVA) on plant density, species richness, live vegetation ground cover (excluding *Selaginella densa*), and bare ground. To enable statistical comparisons among individual zones, treatments and the undisturbed prairie two statistical models were used. One model treated the undisturbed prairie control as a zone, the other set it as a treatment. The model main effects were tested first by the F ratio. Statistically significant effects were explored with Bonferroni comparisons between zones and the undisturbed prairie. All strip/no-strip treatments were contrasted against undisturbed prairie and selected treatments among themselves. Contrasts were made among trench zones. These tests were performed for each of the two years. The statistical models used were:

$$Y_{ij} = \mu + \alpha_I + \varepsilon_{ij}$$

where: μ = grand mean.

α_I = effect of treatment.

ε_{ij} = error term.

and

$$Y_{ij} = \mu + \alpha_I + \varepsilon_{ij}$$

where: μ = grand mean.

α_I = effect of zone.

ε_{ij} = error term.

Analysis of variance was used to determine statistical differences between means of germinated seed numbers from each treatment at each site. Stripped treatments were contrasted against no-strip treatments. The statistical model was:

$$Y_{ij} = \mu + \alpha_I + \varepsilon_{ij}$$

where: μ = grand mean.

α_I = effect of treatment at each site.

ε_{ij} = error term.

Plant species were grouped to make meaningful comparisons across sites because many plant species with similar ecological characteristics (e.g. introduced annuals, native bunch grasses) occurred only at one site but were abundant overall. Eleven groups were established: native bunch grasses, native rhizomatous grasses, grass seedlings, native forb increasers (*Artemisia* sp), native forbs, sedges, introduced grasses, introduced annuals, introduced perennials and shrubs.

4.0 Results and Discussion

4.1 Plant Density

Plant density on all RoW zones except no-strip/no-seed work and strip/no-seed spoil was significantly lower than the undisturbed prairie in both study years despite a general increase from first to second year (Tables 3.1, B.47 to B.58, B.72 to B.84). The largest increase occurred on the strip/no-seed trench where mean plant density rose from 1.1 to 9.8 plants 0.1 m^{-2}. That change is mainly due to establishment of a large number of introduced annuals and, to a much lesser extent, increases in native rhizomatous grasses, sedges and increaser forbs. Among trench zones, no statistically significant differences in plant density occurred until the second year. By then, due to establishment of introduced annuals, plant density was significantly higher in the strip/no-seed than no-strip/no-seed trench. Plant density on the strip/seed trench was also significantly higher than the no-strip/no-seed trench due to increases in seeded grasses and introduced annuals.

Plant density on all strip and no-strip treatments remained significantly lower than the undisturbed prairie over the two study years (Tables 3.6). Plant density was also significantly lower on stripped than no-strip treatments in both years due to the smaller overall disturbance on no-strip treatments. Plant density was marginally higher on the no-strip/no-seed compared to no-strip/seed treatments in both years, significantly so in 1997. In spoil and work zones of strip and no-strip treatments density of native bunch grasses decreased while native rhizomatous grasses increased (Table 3.5). Sedges disappeared from those zones of the seed compared to no-seed treatment. By the second year seeded grasses appeared in the seeded treatment. Plant density in the strip/no-seed treatment was significantly lower than the strip/seed treatment in 1997 but by 1998 had reversed. The increase in seeded grasses in the seeded treatment was overshadowed by the increase in introduced annuals in the no-seed treatment. Two factors may be responsible: competition from seeded grasses suppressed weed growth in the seeded treatment and cultivation by seeding killed some weeds.

4.2 Species Richness

Species richness increased in all RoW zones from 1997 to 1998 (Table 3.2). In five of 12 cases RoW zones were not significantly lower than the undisturbed prairie by 1998. These are areas of highest intact native prairie and include three no-strip work and spoil treatments and two stripped spoil treatments. Species richness was significantly less in the no-strip/no-seed trench than any seeded trench as a result of seeded grasses and introduced annuals. More introduced annuals in the strip/seed trench increased richness compared to the no-strip/seed trench.

Species richness was significantly higher on undisturbed prairie than any treatment over both years (Table 3.7). As a result of less overall disturbance to the prairie surface no-strip had significantly more species than strip treatments in both years. Seeding added significantly to species richness in both strip and no-strip treatments, again over both years.

4.3 Live Vegetation Ground Cover

Live vegetation ground cover was significantly higher on undisturbed prairie than on any RoW zone in 1997 (Tables 3.3, B.35 to B.46, B.59 to B.71). By 1998, cover increased on all RoW zones and 8 of the 12 zones were no longer significantly lower than the undisturbed prairie. Expansion of rhizomatous grasses in the intact prairie and growth of seeded grasses increased ground cover in no-strip treatments. Growth of seeded grasses and introduced annuals increased ground cover on strip treatments. Among trench zones there were no significant differences in ground cover in 1997 and by 1998 only the no-strip/no-seed and strip/seed trenches were significantly different. However, the lack of statistical significance should not mask the fact that ground cover was generally higher on strip versus no-strip trenches and seeding did result in more ground cover.

Live vegetation ground cover was significantly higher on undisturbed prairie than on any strip/no-strip treatment in 1997 but by 1998 only the difference between it and strip/no-seed remained so (Table 3.8). In 1997 ground cover was significantly higher on no-strip/no-seed than strip no-seed but as a result of the large increases in introduced annuals on strip/no-seed it was not significant by 1998. The difference in ground cover on no-strip/no-seed and no-strip/seed was not significant in either year and although it began higher on no-strip/no-seed that relationship reversed. Ground cover on no-strip/seed was consistently higher than strip/seed but the difference was significant only in 1997. Ground cover on strip/seed began marginally higher than strip/no-seed but increased markedly so that by 1998 it was significantly higher.

4.4 Bare Ground

Bare ground was higher on all RoW zones than undisturbed prairie in both years (Tables 3.4, b.85). Little club moss (*Selaginella densa*), which occupied over 60% of the prairie surface, was greatly reduced in all disturbed, especially stripped treatments. The general lack of litter on disturbed areas also contributed to large differences in bare ground between them and the undisturbed prairie. In the five disturbed zones where bare ground increased over time there was a corresponding decrease in the amount of little club moss. Considering erosion is more likely in areas with less than 15% bare ground, these sites all have severe erosion potential.

All strip/no-strip treatments had significantly more bare ground than undisturbed prairie in both years (Table 3.9). No-strip treatments had significantly less bare ground than strip ones in both years. Seeding resulted in less bare ground in strip/seed than in strip/no-seed treatments by 1998, but not in 1997. This is due to large numbers of introduced annuals in the strip/no-seed treatment. Seeding also affected bare ground on no-strip treatments, being significantly higher on the no-seed portion in 1997 but not in 1998.

4.5 Seedbank

Significantly (contrast probability = 0.0095) more seedlings emerged in soil collected from stripped compared to no-strip treatments. A total of 38 seedlings were counted, 27 from strip treatments (Table 3.10). Admixing of soil horizons in no-strip treatments, and therefore dilution of topsoil, is the likely explanation. Species identification must be inferred, however, from the 1998 trench vegetation data the majority of emerged seedlings were introduced annuals. Forty-two percent of seedlings emerged within 16 days and by 23 days 63% had emerged.

5.0 Comparisons to Other Research and Practical Applications

Disturbance resulted in establishment of early successional plant communities reported in several other studies of disturbed plant community dynamics. The most surprising result was the lack of statistically significant differences in plant density or ground cover by the developing vegetation in topsoil on the stripped and seeded treatment or the topsoil/subsoil mix on the no-strip/seed treatment. However, as suggested by Adams et al. (1996), in arid regions with shallow topsoil of low organic matter and nutrient content the difference in growth medium may be insignificant for plant growth.

The competitive exclusion of weeds by seeded grasses was clearly shown in the strip/seed compared to strip/no-seed treatments. The results show that certain characteristics make species more, or less resistant to disturbance and enable them to survive, and in some cases thrive, in a disturbed environment. Other species, less well adapted to disturbance, decline in abundance and/or perish.

The strip/no-strip research emphasizes the benefits of minimal disturbance construction. By measures commonly used to judge reclamation success the no-strip treatment was clearly better than the strip treatment. It had less bare ground more original vegetation remained intact. The suppression of weed growth by seeded grasses is also important. The contribution made by the seedbank to the revegetation process came primarily from introduced annual weeds.

6.0 Conclusions

1. No-strip pipeline construction resulted in a much smaller initial disturbance and conserved more of the initial plant community than conventional right-of-way stripping construction.
2. Seeding appropriate native grasses in pipeline reclamation on native prairie suppressed weed growth, increased species richness and contributed to groundcover on no-strip treatments.
3. Stored propagules in the prairie seedbank contributed to increased ground cover and species richness, however, the contribution of desirable native species was small as weedy annuals dominated.
4. Admixing of soil horizons diluted the seedbank in no-strip treatments.
5. Bare ground increased on no-strip treatments from the destruction of little club moss.

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Table 3.1. Plant density (number of plants 0.1 m^{-2}) on right-of-way zones and undisturbed prairie at the strip/no-strip research sites in 1997 and 1998.

		1997		1998	
Right-of-Way Zone	n	Mean	SD	Mean	SD
Undisturbed prairie vs:	60	34.2	13.6	32.8	17.8
No-strip/no-seed spoil	60	22.2*	18.8	22.0*	18.6
No-strip/no-seed trench	60	0.3*	0.9	1.4*	1.6
No-strip/no-seed work	60	31.1	24.8	32.0	22.4
No-strip/seed spoil	60	18.1*	12.6	21.3*	13.5
No-strip/seed trench	59	3.6*	3.8	4.4*	2.5
No-strip/seed work	60	23.4*	16.3	21.7*	14.6
Strip/no-seed spoil	20	33.3	28.4	26.8	15.6
Strip/no-seed trench	50	1.1*	1.5	9.8*	14.7
Strip/no-seed work	50	1.8*	3.1	4.6*	5.2
Strip/seed spoil	60	16.7*	13.4	17.6*	14.1
Strip/seed trench	60	3.8*	4.0	6.9*	7.3
Strip/seed work	60	4.8*	5.3	5.0*	4.4

* = significantly different from undisturbed prairie by Bonferroni comparison at $\alpha = 0.05$
SD: standard deviation

Table 3.2. Species richness (number of species 0.1 m^{-2}) on right-of-way zones and undisturbed prairie at the strip/no-strip research sites in 1997 and 1998.

		1997		1998	
Right-of-Way Zone	n	Mean	SD	Mean	SD
Undisturbed prairie vs:	60	5.3	1.6	6.0	2.2
No-strip/no-seed spoil	60	3.9*	2.1	4.4*	2.7
No-strip/no-seed trench	60	0.2*	0.6	1.2*	1.2
No-strip/no-seed work	60	4.6	2.3	5.2	2.2
No-strip/seed spoil	60	4.3	2.0	5.4	2.2
No-strip/seed trench	59	1.7*	1.5	3.1*	1.2
No-strip/seed work	60	4.6	1.7	5.7	2.3
Strip/no-seed spoil	20	5.6	2.1	6.4	1.8
Strip/no-seed trench	50	0.8*	1.0	2.5*	2.2
Strip/no-seed work	50	1.0*	1.0	2.3*	1.7
Strip/seed spoil	60	3.9*	2.1	5.1	2.4
Strip/seed trench	60	1.9*	1.2	3.6*	1.4
Strip/seed work	60	2.0*	1.4	3.3*	1.8

* = significantly different from undisturbed prairie by Bonferroni comparison at $\alpha = 0.05$
SD: standard deviation

Table 3.3. Live vegetation ground cover (%) on right-of-way zones and undisturbed prairie at the strip/no-strip research sites in 1997 and 1998.

		1997		1998	
Right-of-Way Zone	n	Mean	SD	Mean	SD
Undisturbed prairie vs:	60	5.0	2.8	5.2	2.5
No-strip/no-seed spoil	60	2.5*	2.5	4.2	3.2
No-strip/no-seed trench	60	0.0*	0.1	1.7*	3.5
No-strip/no-seed work	60	3.5*	3.4	7.0	4.5
No-strip/seed spoil	60	2.2*	2.4	5.6	3.8
No-strip/seed trench	59	0.1*	0.1	2.2*	2.0
No-strip/seed work	60	2.6*	2.4	7.0	4.5
Strip/no-seed spoil	20	2.3*	2.2	7.2	3.2
Strip/no-seed trench	48	0.2*	0.4	2.0*	2.4
Strip/no-seed work	48	0.4*	0.6	2.1*	2.1
Strip/seed spoil	60	2.0*	3.2	5.4	3.7
Strip/seed trench	57	0.2*	0.4	3.4	3.1
Strip/seed work	58	0.3*	0.8	4.6	4.6

* = significantly different from undisturbed prairie by Bonferroni comparison at $\alpha = 0.05$
SD: standard deviation

Table 3.4. Bare ground (%) on right-of-way zones and undisturbed prairie at the strip/no-strip research sites in 1997 and 1998.

		1997		1998	
Right-of-Way Zone	n	Mean	SD	Mean	SD
Undisturbed prairie vs:	60	1.2	2.2	5.7	15.9
No-strip/no-seed spoil	60	62.5*	43.7	71.0*	35.7
No-strip/no-seed trench	60	98.6*	1.8	95.4*	4.6
No-strip/no-seed work	60	65.4*	38.6	71.8*	28.0
No-strip/seed spoil	60	75.7*	36.1	77.5*	31.6
No-strip/seed trench	60	98.6*	1.7	95.3*	3.5
No-strip/seed work	60	70.1*	34.5	74.7*	27.4
Strip/no-seed spoil	20	58.6*	45.3	76.7*	27.6
Strip/no-seed trench	50	98.7*	1.7	94.8*	5.0
Strip/no-seed work	50	98.8*	1.3	95.3*	6.5
Strip/seed spoil	60	79.1*	34.1	75.6*	35.4
Strip/seed trench	60	99.0*	0.8	94.7*	3.4
Strip/seed work	60	98.5*	1.6	93.6*	5.2

* = significantly different from undisturbed prairie by Bonferroni comparison at $\alpha = 0.05$
SD: standard deviation

Table 3.5. Grouped species density on disturbed zones at the strip/no-strip research sites in 1997 and 1998.

		1997		1998	
Right-of-Way Zone	Group	Mean	SD	Mean	SD
no-strip/no-seed spoil	native bunch grasses	7.2	7.9	4.5	5.4
	rhizomatous native grasses	2.0	2.8	4.3	5.5
	sedge	11.1	14.5	11.0	16.4
	grass seedlings	0.0	0.0	0.0	0.0
	introduced grasses	0.0	0.0	0.0	0.0
	native forbs	1.6	2.7	1.7	3.2
	native forb increasers	0.3	1.0	0.1	0.4
	introduced annuals	0.0	0.1	0.5	2.6
	introduced perennials	0.0	0.0	0.0	0.0
	shrubs	0.0	0.0	0.0	0.0
no-strip/no-seed trench	native bunch grasses	0.1	0.3	0.3	0.8
	rhizomatous native grasses	0.0	0.1	0.2	0.5
	sedge	0.2	0.7	0.0	0.3
	grass seedlings	0.0	0.0	0.0	0.0
	introduced grasses	0.0	0.0	0.0	0.0
	native forbs	0.0	0.0	0.0	0.1
	native forb increasers	0.0	0.0	0.1	0.3
	introduced annuals	0.0	0.0	0.7	1.2
	introduced perennials	0.0	0.0	0.0	0.2
	shrubs	0.0	0.0	0.0	0.0
no-strip/no-seed work	native bunch grasses	9.6	11.9	6.2	6.1
	rhizomatous native grasses	2.2	2.6	3.1	3.1
	sedge	15.8	20.4	19.3	19.5
	grass seedlings	0.0	0.0	0.0	0.0
	introduced grasses	0.0	0.0	0.0	0.0
	native forbs	3.2	5.5	2.7	4.4
	native forb increasers	0.4	1.1	0.4	1.1
	introduced annuals	0.1	0.3	0.2	1.2
	introduced perennials	0.0	0.3	0.0	0.0
	shrubs	0.0	0.0	0.0	0.0

Table 3.5. Grouped species density on disturbed zones at the strip/no-strip research sites in 1997 and 1998. (cont'd)

		1997		1998	
Right-of-Way Zone	Group	Mean	SD	Mean	SD
No-strip/seed spoil	native bunch grasses	5.8	5.6	5.1	4.4
	rhizomatous native grasses	2.7	3.1	5.3	6.4
	sedge	7.7	11.2	8.9	10.1
	grass seedlings	0.7	1.7	0.0	0.1
	introduced grasses	0.1	0.4	0.2	0.5
	native forbs	0.8	1.5	1.0	1.6
	native forb increasers	0.3	0.9	0.1	0.5
	introduced annuals	0.0	0.0	0.7	3.1
	introduced perennials	0.0	0.0	0.0	0.0
	shrubs	0.0	0.2	0.0	0.0
No-strip/seed trench	native bunch grasses	1.1	1.5	1.8	1.3
	rhizomatous native grasses	0.7	1.0	1.4	1.6
	sedge	0.4	1.1	0.2	0.6
	grass seedlings	1.5	2.5	0.3	0.9
	introduced grasses	0.0	0.0	0.0	0.0
	native forbs	0.0	0.0	0.1	0.3
	native forb increasers	0.0	0.0	0.0	0.2
	introduced annuals	0.0	0.0	0.6	1.3
	introduced perennials	0.0	0.0	0.0	0.1
	shrubs	0.0	0.0	0.0	0.0
No-strip/seed work	native bunch grasses	6.1	5.0	6.0	5.1
	rhizomatous native grasses	2.5	2.8	3.9	5.2
	sedge	12.6	13.5	9.7	11.1
	grass seedlings	0.3	0.8	0.0	0.0
	introduced grasses	0.0	0.0	0.0	0.0
	native forbs	1.7	3.0	1.5	2.0
	native forb increasers	0.1	0.3	0.1	0.3
	introduced annuals	0.1	0.5	0.6	1.3
	introduced perennials	0.0	0.0	0.0	0.0
	shrubs	0.0	0.0	0.0	0.0

Table 3.5. Grouped species density on disturbed zones at the strip/no-strip research sites in 1997 and 1998. (cont'd)

Right-of-Way Zone	Group	1997 Mean	1997 SD	1998 Mean	1998 SD
Strip/no-seed spoil	native bunch grasses	7.0	4.9	5.2	5.1
	rhizomatous native grasses	4.9	3.7	9.0	12.7
	sedge	19.2	23.0	7.4	9.5
	introduced grasses	0.0	0.0	0.0	0.0
	native forbs	1.4	1.9	1.3	2.4
	native forb increasers	0.4	0.8	0.3	0.7
	introduced annuals	0.0	0.0	3.3	5.8
	introduced perennials	0.0	0.0	0.0	0.0
	shrubs	0.3	0.9	0.4	0.9
Strip/no-seed trench	native bunch grasses	0.3	0.6	0.6	1.1
	rhizomatous native grasses	0.0	0.1	0.3	0.8
	sedge	0.2	0.8	0.3	0.8
	grass seedlings	0.1	0.3	0.1	0.2
	introduced grasses	0.0	0.0	0.0	0.0
	native forbs	0.2	0.5	0.2	0.5
	native forb increasers	0.1	0.2	0.1	0.3
	introduced annuals	0.1	0.2	8.2	13.6
	introduced perennials	0.0	0.0	0.0	0.0
	shrubs	0.2	0.7	0.1	0.4
Strip/no-seed work	native bunch grasses	0.5	1.0	0.5	0.7
	rhizomatous native grasses	0.2	0.6	0.2	0.6
	sedge	0.6	2.0	0.2	0.8
	grass seedlings	0.1	0.3	0.1	0.3
	introduced grasses	0.0	0.0	0.0	0.0
	native forbs	0.3	0.5	0.2	0.5
	native forb increasers	0.1	0.4	0.1	0.3
	introduced annuals	0.1	0.2	3.2	4.9
	introduced perennials	0.0	0.0	0.0	0.0
	shrubs	0.0	0.1	0.0	0.1

Table 3.5 Grouped species density on disturbed zones at the strip/no-strip research sites in 1997 and 1998. (cont'd)

		1997		1998	
Right-of-Way Zone	Group	Mean	SD	Mean	SD
Strip/seed spoil	native bunch grasses	5.8	5.8	4.4	3.6
	rhizomatous native grasses	2.4	2.8	4.1	5.3
	sedge	6.7	8.9	7.5	8.4
	grass seedlings	1.0	2.6	0.2	0.7
	introduced grasses	0.1	0.3	0.0	0.0
	native forbs	0.7	1.2	0.7	1.1
	native forb increasers	0.0	0.2	0.2	0.7
	introduced annuals	0.0	0.0	0.4	0.9
	introduced perennials	0.0	0.1	0.0	0.1
	shrubs	0.1	0.3	0.0	0.1
Strip/seed trench	native bunch grasses	1.0	1.4	1.6	1.1
	rhizomatous native grasses	0.7	1.0	1.7	1.9
	sedge	0.1	0.3	0.2	1.0
	grass seedlings	1.8	3.6	0.3	0.7
	introduced grasses	0.0	0.1	0.0	0.2
	native forbs	0.2	0.7	0.1	0.5
	native forb increasers	0.1	0.3	0.1	0.3
	introduced annuals	0.0	0.1	2.8	6.6
	introduced perennials	0.0	0.1	0.0	0.0
	shrubs	0.0	0.0	0.0	0.0
Strip/seed work	native bunch grasses	1.0	1.2	1.5	1.3
	rhizomatous native grasses	0.9	1.7	1.6	1.9
	sedge	0.6	2.1	0.3	1.5
	grass seedlings	1.8	3.6	0.2	0.7
	introduced grasses	0.1	0.2	0.0	0.0
	native forbs	0.4	1.2	0.5	2.1
	native forb increasers	0.1	0.2	0.1	0.3
	introduced annuals	0.0	0.0	0.8	2.1
	introduced perennials	0.0	0.0	0.0	0.0
	shrubs	0.0	0.1	0.0	0.0

n = 60, except strip/no-seed spoil = 20, strip/no-seed trench and strip/no-seed work = 50
SD: standard deviation

Table 3.6. Contrast probability values of treatment comparisons of plant density (number of plants 0.1m^{-2}) at the strip/no-strip research sites in 1997 and 1998.

			Contrast	Treatment 1		Treatment 2	
Year	Treatment 1	Treatment 2	Probability	Mean	SD	Mean	SD
1997	Undisturbed vs	No-strip/no-seed	0.0001	34.2	13.6	17.9	22.1
	Undisturbed vs	No-strip/seed	0.0001	34.2	13.6	15.1	14.6
	Undisturbed vs	Strip/no-seed	0.0001	34.2	13.6	6.7	16.6
	Undisturbed vs	Strip/seed	0.0001	34.2	13.6	8.4	10.4
	No-strip/no-seed vs	Strip/no-seed	0.0010	17.9	22.1	6.7	16.6
	No-strip/no-seed vs	No-strip/seed	0.0410	17.9	22.1	15.1	14.6
	No-strip/seed vs	Strip/seed	0.0001	15.1	14.6	8.4	10.4
	Strip/no-seed vs	Strip/seed	0.0125	6.7	16.6	8.4	10.4
	No-strip/no-seed trench vs	No-strip/seed trench	0.1630	0.3	0.9	3.6	3.8
	No-strip/no-seed trench vs	Strip/no-seed trench	0.8978	0.3	0.9	1.1	1.5
	No-strip/no-seed trench vs	Strip/seed trench	0.1488	0.3	0.9	3.8	6.9
	No-strip/seed trench vs	Strip/seed trench	0.9658	3.6	3.8	3.8	6.9
1998	Undisturbed vs	No-strip/no-seed	0.0001	32.8	17.8	18.5	21.0
	Undisturbed vs	No-strip/seed	0.0001	32.8	17.8	15.8	14.1
	Undisturbed vs	Strip/no-seed	0.0001	32.8	17.8	10.5	14.1
	Undisturbed vs	Strip/seed	0.0001	32.8	17.8	9.8	10.9
	No-strip/no-seed vs	Strip/no-seed	0.0032	18.5	21.0	10.5	14.1
	No-strip/no-seed vs	No-strip/seed	0.0596	18.5	21.0	15.8	14.1
	No-strip/seed vs	Strip/seed	0.0001	15.8	14.1	9.8	10.9
	Strip/no-seed vs	Strip/seed	0.0245	10.5	14.1	9.8	10.9
	No-strip/no-seed trench vs	No-strip/seed trench	0.2084	1.4	1.6	4.4	2.5
	No-strip/no-seed trench vs	Strip/no-seed trench	0.0007	1.4	14.7	9.8	14.7
	No-strip/no-seed trench vs	Strip/seed trench	0.0231	1.4	7.3	6.9	7.3
	No-strip/seed trench vs	Strip/seed trench	0.3089	4.4	2.5	6.9	7.3

SD: standard deviation

Table 3.7. Contrast probability values of treatment comparisons of species richness (number of plants $0.1m^{-2}$) at the strip/no-strip research sites in 1997 and 1998.

Year	Treatment 1	Treatment 2	Contrast	Treatment 1		Treatment 2	
			Probability	Mean	SD	Mean	SD
1997	Undisturbed vs	No-strip/no-seed	0.0001	5.3	1.6	2.9	2.7
	Undisturbed vs	No-strip/seed	0.0001	5.3	1.6	3.5	2.2
	Undisturbed vs	Strip/no-seed	0.0001	5.3	1.6	1.7	2.1
	Undisturbed vs	Strip/seed	0.0001	5.3	1.6	2.6	1.9
	No-strip/no-seed vs	Strip/no-seed	0.0225	2.9	2.7	1.7	2.1
	No-strip/no-seed vs	No-strip/seed	0.0007	2.9	2.7	3.5	2.2
	No-strip/seed vs	Strip/seed	0.0001	3.5	2.2	2.6	1.9
	Strip/no-seed vs	Strip/seed	0.5501	1.7	2.1	2.6	1.9
	No-strip/no-seed trench vs	No-strip/seed trench	0.0001	0.2	0.6	1.7	1.5
	No-strip/no-seed trench vs	Strip/no-seed trench	0.0800	0.2	0.6	0.8	1.0
	No-strip/no-seed trench vs	Strip/seed trench	0.0001	0.2	0.6	1.9	1.2
	No-strip/seed trench vs	Strip/seed trench	0.5736	1.7	1.5	1.7	1.2
1998	Undisturbed vs	No-strip/no-seed	0.0001	6.0	2.2	3.6	2.7
	Undisturbed vs	No-strip/seed	0.0001	6.0	2.2	4.7	2.3
	Undisturbed vs	Strip/no-seed	0.0001	6.0	2.2	3.0	2.5
	Undisturbed vs	Strip/seed	0.0001	6.0	2.2	4.0	2.0
	No-strip/no-seed vs	Strip/no-seed	0.6512	3.6	2.7	3.0	2.5
	No-strip/no-seed vs	No-strip/seed	0.0001	3.6	2.7	4.7	2.3
	No-strip/seed vs	Strip/seed	0.0001	4.7	2.3	4.0	2.0
	Strip/no-seed vs	Strip/seed	0.0314	3.0	2.5	4.0	2.0
	No-strip/no-seed trench vs	No-strip/seed trench	0.0001	1.2	1.2	3.1	1.2
	No-strip/no-seed trench vs	Strip/no-seed trench	0.0001	1.2	1.2	2.5	2.2
	No-strip/no-seed trench vs	Strip/seed trench	0.0001	1.2	1.2	3.6	1.4
	No-strip/seed trench vs	Strip/seed trench	0.1246	2.5	2.2	3.6	1.4

Table 3.8. Contrast probability values of treatment comparisons of live vegetation ground cover (%) excluding *Selaginella densa* at the strip/no-strip research sites in 1997 and 1998.

Year	Treatment 1	Treatment 2	Contrast Probability	Treatment 1 Mean	Treatment 1 SD	Treatment 2 Mean	Treatment 2 SD
1997	Undisturbed vs	No-strip/no-seed	0.0001	5.0	2.8	2.0	2.8
	Undisturbed vs	No-strip/seed	0.0001	5.0	2.8	1.6	2.2
	Undisturbed vs	Strip/no-seed	0.0001	5.0	2.8	0.6	1.3
	Undisturbed vs	Strip/seed	0.0001	5.0	2.8	0.9	2.0
	No-strip/no-seed vs	Strip/no-seed	0.0001	2.0	2.8	0.6	1.3
	No-strip/no-seed vs	No-strip/seed	0.0728	2.0	2.8	1.6	2.2
	No-strip/seed vs	Strip/seed	0.0005	1.6	2.2	0.9	2.1
	Strip/no-seed vs	Strip/seed	0.5802	0.6	1.3	0.9	2.1
	No-strip/no-seed trench vs	No-strip/seed trench	0.9302	0.0	0.1	0.1	0.1
	No-strip/no-seed trench vs	Strip/no-seed trench	0.897	0.0	0.1	0.2	0.4
	No-strip/no-seed trench vs	Strip/seed trench	0.6597	0.0	0.1	0.2	0.4
	No-strip/seed trench vs	Strip/seed trench	0.7248	0.1	0.1	0.2	0.4
1998	Undisturbed vs	No-strip/no-seed	0.0885	5.2	2.5	4.3	4.3
	Undisturbed vs	No-strip/seed	0.6476	5.2	2.5	4.9	4.1
	Undisturbed vs	Strip/no-seed	0.0049	5.2	2.5	2.9	3.1
	Undisturbed vs	Strip/seed	0.1618	5.2	2.5	4.5	3.9
	No-strip/no-seed vs	Strip/no-seed	0.0994	4.3	4.3	2.9	3.1
	No-strip/no-seed vs	No-strip/seed	0.0782	4.3	4.3	4.9	4.1
	No-strip/seed vs	Strip/seed	0.1827	4.9	4.1	4.5	3.9
	Strip/no-seed vs	Strip/seed	0.0437	2.9	3.1	4.5	3.9
	No-strip/no-seed trench vs	No-strip/seed trench	0.3881	1.7	3.5	2.2	2.0
	No-strip/no-seed trench vs	Strip/no-seed trench	0.4638	1.7	3.5	2.0	2.4
	No-strip/no-seed trench vs	Strip/seed trench	0.0063	1.7	3.5	3.4	3.1
	No-strip/seed trench vs	Strip/seed trench	0.0607	2.2	2.0	3.4	3.1

Table 3.9. Contrast probability values of treatment comparisons of bare ground (%) at the strip/no-strip research sites in 1997 and 1998.

			Contrast	Treatment 1		Treatment 2	
Year	Treatment 1	Treatment 2	Probability	Mean	SD	Mean	SD
1997	Undisturbed vs	No-strip/no-seed	0.0001	1.2	2.2	75.5	37.3
	Undisturbed vs	No-strip/seed	0.0001	1.2	2.2	81.3	31.3
	Undisturbed vs	Strip/no-seed	0.0001	1.2	2.2	92.1	23.5
	Undisturbed vs	Strip/seed	0.0001	1.2	2.2	92.2	21.7
	No-strip/no-seed vs	Strip/no-seed	0.0009	75.5	37.3	92.1	23.5
	No-strip/no-seed vs	No-strip/seed	0.0251	75.5	37.3	81.3	31.3
	No-strip/seed vs	Strip/seed	0.0001	81.3	31.3	92.2	21.7
	Strip/no-seed vs	Strip/seed	0.0483	92.1	23.5	92.2	21.7
	No-strip/no-seed trench vs	No-strip/seed trench	0.9986	98.6	1.8	98.6	1.7
	No-strip/no-seed trench vs	Strip/no-seed trench	0.9143	98.6	1.8	98.7	1.7
	No-strip/no-seed trench vs	Strip/seed trench	0.9186	98.6	1.8	99.0	0.8
	No-strip/seed trench vs	Strip/seed trench	0.9172	98.6	1.7	99.0	0.8
1998	Undisturbed vs	No-strip/no-seed	0.0001	5.7	15.9	79.9	28.0
	Undisturbed vs	No-strip/seed	0.0001	5.7	15.9	82.5	25.8
	Undisturbed vs	Strip/no-seed	0.0001	5.7	15.9	92.0	14.0
	Undisturbed vs	Strip/seed	0.0001	5.7	15.9	88.0	22.4
	No-strip/no-seed vs	Strip/no-seed	0.0003	79.9	28.0	92.0	14.0
	No-strip/no-seed vs	No-strip/seed	0.1821	79.9	28.0	82.5	25.8
	No-strip/seed vs	Strip/seed	0.0168	82.8	25.8	88.0	22.4
	Strip/no-seed vs	Strip/seed	0.6555	92.0	14.0	88.0	22.4
	No-strip/no-seed trench vs	No-strip/seed trench	0.9741	95.4	4.6	95.3	3.5
	No-strip/no-seed trench vs	Strip/no-seed trench	0.8351	95.4	4.6	94.8	5.0
	No-strip/no-seed trench vs	Strip/seed trench	0.8483	95.4	4.6	94.7	3.4
	No-strip/seed trench vs	Strip/seed trench	0.8738	95.3	3.5	94.7	3.4

Table 3.10. Emerged seedlings from the seedbank in the trench zone at the strip/no-strip research sites.

Site	Treatment	Mean	SD
Jenner North	No-strip/no-seed	0.04 b	0.21
	No-strip/seed	0.02 b	0.15
	Strip/no-seed	0.0 b	0.0
	Strip/seed	0.11 b	0.32
Jenner South	No-strip/no-seed	0.11 b	0.32
	No-strip/seed	0.07 b	0.25
	Strip/no-seed	0.33 a	0.64
	Strip/seed	0.15 ab	0.37

n = 45

SD: standard deviation

Means with the same letter are not significantly different at $p \leq 0.05$

IV. SYNTHESIS

1.0 Summary of Research

The research discussed in this thesis was undertaken to evaluate atypical pipeline construction and reclamation practices, sod salvage and replacement and no-strip rights-of-way, aimed at promoting restoration of the disturbed ecosystem.

The disturbance resulting from salvaging and transplanting native prairie sod caused the plant community to revert to an earlier successional state wherein some of the late seral plant species were displaced by introduced annuals and more aggressive, primarily rhizomatous, introduced and native grasses. The extent of this shift depends, to a large degree, on the abundance of those species in the initial and surrounding plant communities.

In the strip/no-strip experiment disturbance resulted in establishment of early successional plant communities. The most surprising result was the lack of statistically significant differences in plant density or ground cover by the developing vegetation in topsoil on the stripped and seeded treatment or the topsoil/subsoil mix on the no-strip/seed treatment. Competitive exclusion of weeds by seeded grasses was clearly exhibited.

The results from both experiments support previous claims that certain characteristics make different species more or less resistant to disturbance and enable them to survive, and in some cases, thrive, in a disturbed environment. Other species, less well adapted to disturbance, decline in abundance and/or perish.

The time frame over which this research was conducted is too short to make definitive statements regarding the eventual outcome of plant community development in either experiment. However, it seems likely that the salvaged sod will return to its pre-disturbance state more quickly than seeded areas. Plant community development is in its very early stages at the strip/no-strip sites and it is impossible to predict the outcome.

2.0 Practical Applications

Salvaging native prairie sod prior to construction, although a significant disturbance in itself, conserved a good representative sample of the predisturbance plant community. Propagules, primarily seed, from many of the species in the transplanted sod are not currently available commercially and may never be. Furthermore, establishment requirements of many of those same species are not well understood. And although the expense of carefully salvaging, storing and transplanting native prairie sod may prohibit its use on very large scale reclamation projects it may be useful in instances when disturbance to highly sensitive areas cannot be avoided or when essentially immediate post-disturbance ground cover is required. Sod salvage may also be useful on a small scale where, rather than salvaging entire, large areas, individual sods could be salvaged and replaced intermittently, for example every few hundred meters along a pipeline right-of-way or a few sods on a 1 hectare wellsite. These individual sods would act primarily as a source of otherwise unavailable propagules thereby promoting restoration of the disturbed areas.

Site selection is a key consideration in sod salvaging efforts. The presence of aggressive exotic plants decreases the chances of successful transplanting in proportion to their abundance in the original vegetation.

The strip/no-strip experiment further emphasizes the benefits of minimal disturbance construction. By measures commonly used to judge reclamation success the no-strip treatment was clearly better. It had less bare ground and much more of the original vegetation remained intact. The suppression of weed growth by seeded grasses is also an important practical result from this work. The contribution made by the seedbank to the revegetation process was primarily from introduced weeds that increased ground cover and species richness but did not contribute to a desired plant community composition over the time frame of the research.

The results indicate that minimizing disturbance to existing plant communities during pipeline construction will have a beneficial long-term influence on site restoration. Every reasonable effort should be made to conserve as much of the original plant community as possible on any project on native prairie.

3.0 Future Research

Until such time as we more fully understand the consequences of our industrial activities on this planet we must proceed with caution. In the meantime it is incumbent upon us to make every effort to minimize disturbance and to restore disturbed ecosystems. We don't want to wake up, 50 years hence, to the shocking realization that we have cemented the tunnel shut behind us.

Future research in land reclamation and restoration should be directed toward a better understanding of the long-term implications of the current common practices. We need to re-examine sites with good baseline data over many years to see whether restoration is proceeding or, if not, to try and determine why not. Ecological processes can be slow to manifest themselves and only by undertaking long-term studies will we more fully understand them.

APPENDIX A

SITE SOIL CHARACTERISTICS

Table A.1. Typical profile description of the Hughendon Soil Unit.

Horizon	Depth (cm)	Colour	Texture	Structure	Consistence
Ap	0 - 13	very dark grayish brown	loam	granular	friable
Bm	13 - 25	dark yellowish brown	loam	weak subangular blocky	friable
Ck	25 - 150	yellowish brown	loam clay-loam	massive	friable

Adapted from Leskiw et al. (1993)

Table A.2. Typical profile description of the Purescape Soil Unit.

Horizon	Depth (cm)	Colour	Texture	Structure	Consistence
Ah	0 - 14	very dark grayish brown	loam	granular	friable
Bm	14 - 30	grayish brown	clay loam	fine to medium subangular blocky	friable
Ck	30 - 100	brown	clay loam	massive	firm

Adapted from Leskiw et al. (1993)

Table A.3. Typical profile description of the Bingville Soil Unit.

Horizon	Depth (cm)	Colour	Texture	Structure	Consistence
Ah	0 - 16	dark grayish brown	fine sandy loam	granular	friable
Bm	16 - 45	dark grayish brown	sandy loam	angular blocky	friable
Ck	45 - 150	grayish brown	sandy loam	massive	friable

Adapted from Leskiw et al. (1993)

Table A.4. Typical profile description of the Halliday Soil Unit.

Horizon	Depth (cm)	Colour	Texture	Structure	Consistence
Ap	0 - 10	brown	loam sandy loam	granular	friable
AB	10 - 29	brown	loam	subangular blocky	friable
Bnt	29 - 50	grayish brown	clay loam	columnar	firm
Csk	50 - 150	yellowish brown	clay loam loam	massive	friable

Adapted from Leskiw et al. (1993)

Table A.5. Hardisty soil chemical and particle size distribution properties.

			Chemical Property			Particle Size Distribution			
Right-of-Way Zone	Depth (cm)	n	Chemical parameter	Mean	SD	Fraction	Mean	SD	Texture Class
Undisturbed prairie	0 - 5	1	EC	1.4	.	sand	52.9	.	loam sandy loam
		1	pH	6.6	.	silt	40.5	.	
		1	C	3.6	.	clay	6.7	.	
	5 - 15	1	EC	0.7	.	sand	51.7	.	loam sandy loam
		1	pH	6.4	.	silt	31.1	.	
		1	C	3.6	.	clay	17.2	.	
	15 - 30	1	EC	0.7	.	sand	57.1	.	sandy clay loam
		1	pH	6.7	.	silt	21.8	.	
		1	C	1.7	.	clay	21.1	.	
	30 - 45	1	EC	0.6	.	sand	53.4	.	sandy clay loam
		1	pH	6.5	.	silt	22.2	.	
		1	C	1.8	.	clay	24.4	.	
Seeded spoil	0 - 5	3	EC	1.6	0.24	sand	53.6	1.6	sandy loam
		3	pH	7.2	0.25	silt	29.4	1.3	
		3	C	3.7	0.25	clay	17.1	2.2	
Seeded trench	0 - 5	3	EC	1.8	0.46	sand	53.1	1.4	sandy loam
		3	pH	7.3	0.51	silt	28.9	1.4	
		3	C	3.7	0.16	clay	18.0	1.7	
Seeded work	0 - 5	3	EC	1.9	0.59	sand	52.6	0.5	loam sandy loam
		3	pH	7.4	0.28	silt	29.4	1.1	
		3	C	3.5	0.36	clay	18.0	1.0	
Sodded spoil	0 - 5	3	EC	1.5	0.36	sand	54.7	2.2	sandy loam
		3	pH	7.3	0.17	silt	26.5	2.1	
		3	C	3.4	1.41	clay	18.8	4.2	
Sodded trench	0 - 5	3	EC	1.6	0.31	sand	55.3	1.2	sandy loam
		3	pH	7.4	0.15	silt	26.5	0.9	
		3	C	3.0	0.20	clay	18.2	1.0	
Sodded work	0 - 5	3	EC	2.0	0.12	sand	54.1	3.6	sandy loam
		3	pH	7.5	0.22	silt	28.0	1.4	
		3	C	3.8	0.85	clay	17.9	2.6	

EC: electrical conductivity (mS/cm)
C: total carbon (%)
SD: standard deviation

Table A.6. Hardisty penetration resistance, surface soil moisture and surface bulk density.

	Penetration Resistance (MPa)					Surface Moisture (%)		Surface Bulk Density (Mg m^{-3})	
Right-of-Way Zone	Depth (cm)	n	Mean	SD	n	Mean	SD	Mean	SD
Undisturbed prairie	0	30	0.8	0.6	15	8.4	1.8	1.08	0.09
	2.5	30	2.7	0.7					
	5.0	30	4.0	0.8					
	7.5	30	4.5	0.9					
	10.0	30	4.9	0.9					
	12.5	30	5.0	0.7					
	15.0	30	5.1	0.7					
	20.0	30	5.3	0.4					
Seeded spoil	0	30	0.7	1.0	15	21.1	4.7	1.24	0.10
	2.5	30	2.1	1.3					
	5.0	30	2.9	1.2					
	7.5	30	2.8	1.4					
	10.0	30	2.6	1.4					
	12.5	30	2.6	1.5					
	15.0	30	2.8	1.4					
	20.0	30	3.5	1.3					
Seeded trench	0	30	0.6	0.7	15	20.3	5.3	1.18	0.12
	2.5	30	2.1	1.0					
	5.0	30	2.7	0.9					
	7.5	30	2.6	0.8					
	10.0	30	2.4	0.9					
	12.5	30	2.4	1.1					
	15.0	30	2.4	1.1					
	20.0	30	2.8	1.2					
Seeded work	0	30	0.7	0.6	15	20.1	6.1	1.32	0.09
	2.5	30	2.3	1.2					
	5.0	30	2.9	1.2					
	7.5	30	2.8	1.2					
	10.0	30	2.7	1.4					
	12.5	30	2.7	1.2					
	15.0	30	2.8	1.4					
	20.0	30	3.1	1.5					
Sodded spoil	0	30	0.3	0.4	15	9.6	3.6	1.17	0.21
	2.5	30	1.3	1.1					
	5.0	30	2.1	1.4					
	7.5	30	2.5	1.4					
	10.0	30	2.8	1.5					
	12.5	30	3.4	1.3					
	15.0	30	3.9	1.3					
	20.0	30	4.6	1.1					

Table A.6. Hardisty penetration resistance, surface soil moisture and surface bulk density. (cont'd)

Right-of-Way Zone	Penetration Resistance (MPa) Depth (cm)	n	Mean	SD	Surface Moisture (%) n	Mean	SD	Surface Bulk Density (Mg m^{-3}) Mean	SD
Sodded trench	0	30	0.2	0.1	15	7.5	3.0	1.12	0.13
	2.5	30	0.7	0.5					
	5.0	30	1.3	0.8					
	7.5	30	1.7	0.9					
	10.0	30	2.4	2.8					
	12.5	30	2.5	1.1					
	15.0	30	3.5	1.5					
	20.0	30	4.6	1.2					
Sodded work	0	30	0.6	0.5	15	12.6	4.6	1.21	0.16
	2.5	30	2.8	1.3					
	5.0	30	4.1	1.5					
	7.5	30	4.4	1.5					
	10.0	30	4.5	1.5					
	12.5	30	4.7	1.2					
	15.0	30	4.9	1.0					
	20.0	30	5.1	0.6					

SD: standard deviation

Table A.7. Manyberries soil chemical and particle size distribution properties.

			Chemical Property			Particle Size Distribution			
Right-of-Way Zone	Depth (cm)	n	Chemical parameter	Mean	SD	Fraction	Mean	SD	Texture Class
Undisturbed prairie	0 - 5	1	EC	2.19	1.18	sand	45.0	0.9	loam
		1	pH	6.67	0.25	silt	42.2	4.6	
		1	C	5.45	3.39	clay	12.8	4.0	
	5 - 15	1	EC	0.66	0.07	sand	48.8	2.6	loam
		1	pH	6.49	0.20	silt	29.0	5.5	sandy clay
		1	C	1.84	0.88	clay	22.3	5.1	loam
	15 - 30	1	EC	1.67	0.38	sand	45.0	3.3	clay loam
		1	pH	7.69	0.39	silt	26.4	4.8	loam sandy
		1	C	1.42	0.15	clay	28.5	3.9	clay loam
	30 - 45	1	EC	1.85	0.71	sand	42.0	2.4	clay loam
		1	pH	8.18	0.17	silt	28.5	3.6	
		1	C	1.45	0.15	clay	29.5	5.5	
Seeded spoil	0 - 5	4	EC	2.64	0.61	sand	40.8	2.3	loam
		4	pH	7.78	0.17	silt	38.0	3.7	
		4	C	4.18	1.09	clay	21.1	2.8	
Seeded trench	0 - 5	4	EC	1.74	0.54	sand	42.5	2.4	loam
		4	pH	7.71	0.24	silt	36.8	2.5	
		4	C	4.87	0.74	clay	20.6	1.4	
Seeded work	0 - 5	4	EC	1.81	0.51	sand	42.8	2.6	loam
		4	pH	7.21	0.57	silt	39.1	5.0	
		4	C	4.26	1.72	clay	18.2	3.8	
Sodded spoil	0 - 5	4	EC	2.64	1.38	sand	43.9	3.4	loam
		4	pH	7.64	0.41	silt	33.5	4.3	
		4	C	4.24	0.97	clay	22.6	3.0	
Sodded trench	0 - 5	4	EC	2.36	0.40	sand	42.1	1.5	loam
		4	pH	7.20	0.07	silt	40.2	2.2	
		4	C	5.91	1.31	clay	17.7	1.1	
Sodded work	0 - 5	4	EC	2.10	0.08	sand	41.8	6.9	loam
		4	pH	6.96	0.20	silt	41.3	3.8	
		4	C	5.03	0.76	clay	16.9	4.7	

EC: electrical conductivity (mS/cm)
C: total carbon (%)
SD: standard deviation

Table A.8. Manyberries penetration resistance, surface soil moisture and surface bulk density.

	Penetration Resistance (MPa)				Surface Moisture (%)			Surface Bulk Density (Mg m^{-3})	
Right-of-Way Zone	Depth (cm)	n	Mean	SD	n	Mean	SD	Mean	SD
Undisturbed prairie	0	40	0.8	0.3	20	13.2	2.7	0.94	0.11
	2.5	40	1.3	0.4					
	5.0	40	1.6	0.4					
	7.5	40	1.8	0.5					
	10.0	40	2.5	1.2					
	12.5	40	2.9	1.3					
	15.0	40	3.5	1.2					
	20.0	40	4.5	0.9					
Seeded spoil	0	40	1.7	0.7	20	16.7	3.5	1.30	0.20
	2.5	40	2.2	0.7					
	5.0	40	2.2	0.9					
	7.5	40	2.7	1.0					
	10.0	40	3.1	1.1					
	12.5	40	3.5	1.3					
	15.0	40	3.7	1.3					
	20.0	40	4.0	1.2					
Seeded trench	0	40	1.1	0.5	20	17.4	2.9	1.43	0.17
	2.5	40	1.7	0.6					
	5.0	40	1.7	0.4					
	7.5	40	1.8	0.4					
	10.0	40	2.3	1.2					
	12.5	40	2.6	1.3					
	15.0	40	3.1	1.4					
	20.0	40	3.7	1.4					
Seeded work	0	40	1.3	0.6	20	17.0	2.8	1.35	0.23
	2.5	40	2.2	0.6					
	5.0	40	2.7	0.9					
	7.5	40	3.1	1.2					
	10.0	40	3.2	1.3					
	12.5	40	3.2	1.4					
	15.0	40	3.4	1.4					
	20.0	40	4.0	1.3					
Sodded spoil	0	40	1.0	0.5	20	15.9	2.8	1.24	0.23
	2.5	40	1.9	0.8					
	5.0	40	2.4	1.0					
	7.5	40	2.8	1.2					
	10.0	40	3.2	1.4					
	12.5	40	3.6	1.5					
	15.0	40	3.9	1.5					
	20.0	40	4.2	1.4					

Table A.8. Manyberries penetration resistance, surface soil moisture and surface bulk density. (cont'd)

	Penetration Resistance (MPa)				Surface Moisture (%)			Surface Bulk Density (Mg m^{-3})	
Right-of-Way Zone	Depth (cm)	n	Mean	SD	n	Mean	SD	Mean	SD
Sodded trench	0	40	0.6	0.4	20	15.9	3.4	0.98	0.11
	2.5	40	1.1	0.5					
	5.0	40	1.2	0.6					
	7.5	40	1.6	1.2					
	10.0	40	1.8	1.2					
	12.5	40	2.3	1.3					
	15.0	40	3.0	1.5					
	20.0	40	3.7	1.6					
Sodded work	0	40	1.0	0.4	20	17.9	4.1	1.24	0.12
	2.5	40	2.0	0.7					
	5.0	40	2.2	0.7					
	7.5	40	2.3	0.7					
	10.0	40	2.4	0.8					
	12.5	40	2.8	1.1					
	15.0	40	3.1	1.2					
	20.0	40	3.7	1.3					

SD: standard deviation

Table A.9. Jenner North no-strip/no-seed soil chemical and particle size distribution properties.

			Chemical Property			Particle Size Distribution			
Right-of-Way Zone	Depth (cm)	n	Chemical parameter	Mean	SD	Fraction	Mean	SD	Texture Class
Undisturbed prairie	0 - 5	1	EC	1.13	.	sand	48.2	.	loam
		1	pH	6.95	.	silt	43.5	.	
		1	C	5.23	.	clay	8.3	.	
	5 - 15	1	EC	0.65	.	sand	49.3	.	loam
		1	pH	7.14	.	silt	29.9	.	
		1	C	1.61	.	clay	20.8	.	
	15 - 30	1	EC	1.15	.	sand	48.8	.	loam
		1	pH	8.06	.	silt	27.8	.	
		1	C	1.50	.	clay	23.3	.	
	30 - 45	1	EC	1.10	.	sand	50.5	.	loam
		1	pH	8.36	.	silt	26.8	.	
		1	C	1.86	.	clay	22.7	.	
Spoil	0 - 5	3	EC	1.43	0.37	sand	58.2	13.8	sandy loam
		3	pH	7.60	0.88	silt	34.2	14.0	
		3	C	4.38	3.57	clay	7.6	0.6	
Trench	0 - 5	3	EC	2.30	0.52	sand	68.4	5.0	sandy loam
		3	pH	8.13	0.23	silt	22.5	4.7	
		3	C	1.45	0.30	clay	9.1	0.5	
Work	0 - 5	3	EC	1.29	0.27	sand	54.9	14.6	sandy loam
		3	pH	7.77	0.90	silt	36.0	15.3	
		3	C	3.81	3.32	clay	9.1	1.5	

EC: electrical conductivity (mS/cm)
C: total carbon (%)
SD: standard deviation

Table A.10. Jenner North no-strip/no-seed penetration resistance, surface soil moisture and surface bulk density.

	Penetration Resistance (MPa)				Surface Moisture (%)			Surface Bulk Density (Mg m^{-3})	
Right-of-Way Zone	Depth (cm)	n	Mean	SD	n	Mean	SD	Mean	SD
Undisturbed prairie	0	30	1.5	0.4	15	9.7	2.5	1.07	0.15
	2.5	30	1.8	0.3					
	5.0	30	2.0	0.5					
	7.5	30	2.4	0.7		13.6	5.4	1.12	0.13
	10.0	30	2.8	1.0					
	12.5	30	3.5	1.0					
	15.0	30	4.4	0.9					
	20.0	30	5.0	0.7					
Spoil	0	30	1.5	0.6	15	12.2	4.7	1.29	0.23
	2.5	30	2.5	0.8					
	5.0	30	3.0	1.1					
	7.5	30	3.3	1.2					
	10.0	30	3.5	1.2					
	12.5	30	3.8	1.1					
	15.0	30	4.2	1.1					
	20.0	30	4.9	0.9					
Trench	0	30	2.1	0.7	15	10.0	2.1	1.66	0.06
	2.5	30	9.4	30.3					
	5.0	30	5.0	0.7					
	7.5	30	5.3	0.2					
	10.0	30	5.3	0.1					
	12.5	30	5.4	0.0					
	15.0	30	5.4	0.0					
	20.0	30	5.4	0.0					
Work	0	30	1.7	0.8	15	13.6	5.4	1.12	0.13
	2.5	30	2.7	0.8					
	5.0	30	3.2	0.9					
	7.5	30	3.5	0.9					
	10.0	30	3.7	0.9					
	12.5	30	3.9	0.9					
	15.0	30	4.3	1.0					
	20.0	30	4.5	1.1					

SD: standard deviation

Table A.11. Jenner North no-strip/seed soil chemical and particle size distribution properties.

			Chemical Property			Particle Size Distribution			
Right-of-Way Zone	Depth (cm)	n	Chemical parameter	Mean	SD	Fraction	Mean	SD	Texture Class
Undisturbed prairie	0 - 5	1	EC	0.65	.	sand	63.3	.	sandy loam
		1	pH	6.73	.	silt	28.8	.	
		1	C	1.92	.	clay	8.0	.	
	5 - 15	1	EC	0.45	.	sand	65.5	.	sandy loam
		1	pH	6.94	.	silt	26.3	.	
		1	C	1.00	.	clay	8.2	.	
	15 - 30	1	EC	0.40	.	sand	67.6	.	sandy loam
		1	pH	6.95	.	silt	23.3	.	
		1	C	0.58	.	clay	9.1	.	
	30 - 45	1	EC	0.40	.	sand	67.5	.	sandy loam
		1	pH	7.00	.	silt	20.6	.	
		1	C	0.46	.	clay	12.0	.	
Spoil	0 - 5	3	EC	1.48	0.73	sand	63.9	13.8	sandy loam
		3	pH	7.42	0.27	silt	28.2	14.0	
		3	C	2.19	0.49	clay	7.8	0.6	
Trench	0 - 5	3	EC	2.52	0.18	sand	64.3	5.0	sandy loam
		3	pH	8.06	0.13	silt	25.3	4.7	
		3	C	1.41	0.11	clay	10.3	0.5	
Work	0 - 5	3	EC	1.20	0.17	sand	62.4	14.6	sandy loam
		3	pH	7.21	0.50	silt	29.9	15.3	
		3	C	2.99	0.48	clay	7.7	1.5	

EC: electrical conductivity (mS/cm)
C: total carbon (%)
SD: standard deviation

Table A.12. Jenner North no-strip/seed penetration resistance, surface soil moisture and surface bulk density.

	Penetration Resistance (MPa)				Surface Moisture (%)			Surface Bulk Density (Mg m^{-3})	
Right-of-Way Zone	Depth (cm)	n	Mean	SD	n	Mean	SD	Mean	SD
Undisturbed prairie	0	30	0.8	0.3	15	6.2	2.9	1.18	0.13
	2.5	30	1.5	0.4					
	5.0	30	1.7	0.4					
	7.5	30	1.8	0.5					
	10.0	30	2.0	0.5					
	12.5	30	2.5	0.8					
	15.0	30	3.1	1.1					
	20.0	30	4.8	1.0					
Spoil	0	30	1.4	1.0	15	11.2	4.3	1.49	0.14
	2.5	30	2.6	1.3					
	5.0	30	3.4	1.1					
	7.5	30	3.6	0.9					
	10.0	30	3.7	1.0					
	12.5	30	3.8	0.9					
	15.0	30	3.9	1.0					
	20.0	30	4.1	0.9					
Trench	0	30	1.2	0.7	15	12.5	1.4	1.62	0.10
	2.5	30	3.4	0.9					
	5.0	30	4.9	0.9					
	7.5	30	5.2	0.5					
	10.0	30	5.1	0.6					
	12.5	30	5.1	0.7					
	15.0	30	5.2	0.6					
	20.0	30	5.2	0.5					
Work	0	30	1.3	0.7	15	11.0	2.9	1.42	0.15
	2.5	30	2.7	1.1					
	5.0	30	3.2	0.9					
	7.5	30	3.6	0.7					
	10.0	30	3.9	0.7					
	12.5	30	4.2	0.7					
	15.0	30	4.5	0.8					
	20.0	30	4.8	0.8					

SD: standard deviation

Table A.13. Jenner North strip/no-seed soil chemical and particle size distribution properties.

			Chemical Property			Particle Size Distribution			
Right-of-Way Zone	Depth (cm)	n	Chemical parameter	Mean	SD	Fraction	Mean	SD	Texture Class
Undisturbed prairie	0 - 5	1	EC	0.70	.	sand	67.3	.	sandy loam
		1	pH	7.04	.	silt	26.0	.	
		1	C	2.18	.	clay	6.7	.	
	5 - 15	1	EC	5.00	.	sand	67.4	.	sandy loam
		1	pH	7.12	.	silt	24.7	.	
		1	C	1.02	.	clay	7.9	.	
	15 - 30	1	EC	0.45	.	sand	67.7	.	sandy loam
		1	pH	7.20	.	silt	20.4	.	
		1	C	0.64	.	clay	11.9	.	
	30 - 45	1	EC	0.45	.	sand	70.8	.	sandy loam
		1	pH	7.33	.	silt	18.0	.	
		1	C	0.47	.	clay	11.2	.	
Spoil	0 - 5	3	EC	1.48	0.14	sand	65.9	13.8	sandy loam
		3	pH	8.02	0.07	silt	26.0	14.0	
		3	C	1.94	0.16	clay	8.2	0.6	
Trench	0 - 5	3	EC	1.13	0.19	sand	70.9	5.0	sandy loam
		3	pH	8.25	0.17	silt	19.1	4.7	
		3	C	1.10	0.22	clay	10.1	0.5	
Work	0 - 5	3	EC	1.32	0.15	sand	72.9	14.6	sandy loam
		3	pH	8.27	0.11	silt	17.3	15.3	
		3	C	1.03	0.04	clay	9.8	1.5	

EC: electrical conductivity (mS/cm)
C: total carbon (%)
SD: standard deviation

Table A.14. Jenner North strip/no-seed penetration resistance, surface soil moisture and surface bulk density.

	Penetration Resistance (MPa)				Surface Moisture (%)			Surface Bulk Density (Mg m^{-3})	
Right-of-Way Zone	Depth (cm)	n	Mean	SD	n	Mean	SD	Mean	SD
Undisturbed prairie	0	30	1.4	0.5	15	5.6	3.0	1.14	0.13
	2.5	30	1.6	0.4					
	5.0	30	1.8	0.4					
	7.5	30	2.0	0.4					
	10.0	30	2.4	0.7					
	12.5	30	2.8	0.9					
	15.0	30	3.5	1.1					
	20.0	30	5.1	0.7					
Spoil	0	30	1.6	1.1	15	10.3	3.8	1.57	0.08
	2.5	30	3.0	1.4					
	5.0	30	3.5	1.2					
	7.5	30	3.7	1.1					
	10.0	30	4.1	1.0					
	12.5	30	4.2	1.0					
	15.0	30	4.3	1.0					
	20.0	30	4.5	1.0					
Trench	0	30	2.3	1.0	15	10.7	2.1	1.65	0.09
	2.5	30	3.7	1.1					
	5.0	30	4.3	1.1					
	7.5	30	4.8	1.0					
	10.0	30	5.1	0.7					
	12.5	30	5.2	0.6					
	15.0	30	5.3	0.5					
	20.0	30	5.2	0.6					
Work	0	30	1.7	0.8	15	12.9	3.6	1.60	0.15
	2.5	30	3.3	1.1					
	5.0	30	3.8	1.2					
	7.5	30	3.9	1.4					
	10.0	30	4.0	1.4					
	12.5	30	4.1	1.3					
	15.0	30	4.2	1.3					
	20.0	30	4.5	1.1					

SD: standard deviation

Table A.15. Jenner North strip/seed soil chemical and particle size distribution properties.

			Chemical Property			Particle Size Distribution			
Right-of-Way Zone	Depth (cm)	n	Chemical parameter	Mean	SD	Fraction	Mean	SD	Texture Class
Undisturbed prairie	0 - 5	1	EC	0.50	.	sand	73.7	.	sandy loam
		1	pH	6.96	.	silt	20.1	.	
		1	C	2.06	.	clay	6.2	.	
	5 - 15	1	EC	0.45	.	sand	75.7	.	sandy loam
		1	pH	6.83	.	silt	18.0	.	loamy sand
		1	C	1.13	.	clay	6.3	.	
	15 - 30	1	EC	0.45	.	sand	73.6	.	sandy loam
		1	pH	6.85	.	silt	16.6	.	
		1	C	0.73	.	clay	9.8	.	
	30 - 45	1	EC	0.55	.	sand	72.4	.	sandy loam
		1	pH	6.94	.	silt	17.7	.	
		1	C	0.66	.	clay	9.9	.	
Spoil	0 - 5	3	EC	1.82	0.59	sand	71.8	13.8	sandy loam
		3	pH	7.89	0.23	silt	19.3	14.0	
		3	C	1.80	0.34	clay	8.9	0.6	
Trench	0 - 5	3	EC	1.70	0.28	sand	71.5	5.0	sandy loam
		3	pH	8.00	0.10	silt	19.4	4.7	
		3	C	1.42	0.09	clay	9.1	0.5	
Work	0 - 5	3	EC	1.52	0.29	sand	71.7	14.6	sandy loam
		3	pH	8.11	0.10	silt	18.9	15.3	
		3	C	1.27	0.19	clay	9.5	1.5	

EC: electrical conductivity (mS/cm)
C: total carbon (%)
SD: standard deviation

Table A.16. Jenner North strip/seed penetration resistance, surface soil moisture and surface bulk density.

	Penetration Resistance (MPa)				Surface Moisture (%)			Surface Bulk Density (Mg m^{-3})	
Right-of-Way Zone	Depth (cm)	n	Mean	SD	n	Mean	SD	Mean	SD
Undisturbed prairie	0	30	1.2	0.4	15	2.6	1.6	1.24	0.07
	2.5	30	1.7	0.3					
	5.0	30	1.9	0.3					
	7.5	30	2.2	0.6					
	10.0	30	2.4	0.7					
	12.5	30	2.6	0.8					
	15.0	30	3.3	1.0					
	20.0	30	5.0	0.8					
Spoil	0	30	1.5	1.0	15	7.1	3.2	1.61	0.10
	2.5	30	3.0	1.4					
	5.0	30	3.5	1.2					
	7.5	30	3.8	1.2					
	10.0	30	3.9	1.1					
	12.5	30	4.0	1.2					
	15.0	30	4.1	1.2					
	20.0	30	4.5	1.0					
Trench	0	30	1.6	1.0	15	10.5	1.2	1.63	0.07
	2.5	30	3.3	1.1					
	5.0	30	3.9	1.0					
	7.5	30	4.4	1.0					
	10.0	30	4.9	0.7					
	12.5	30	5.0	0.8					
	15.0	30	5.0	0.8					
	20.0	30	5.1	0.6					
Work	0	30	1.4	0.7	15	10.4	1.5	1.73	0.06
	2.5	30	3.6	1.1					
	5.0	30	4.3	1.0					
	7.5	30	4.5	1.0					
	10.0	30	4.7	1.0					
	12.5	30	4.8	0.9					
	15.0	30	5.0	0.8					
	20.0	30	5.1	0.7					

SD: standard deviation

Table A.17. Jenner South no-strip/no-seed soil chemical properties and particle size distribution properties.

			Chemical Property			Particle Size Distribution			
Right-of-Way Zone	Depth (cm)	n	Chemical parameter	Mean	SD	Fraction	Mean	SD	Texture Class
Undisturbed prairie	0 - 5	1	EC	1.80	.	sand	40.3	.	loam
		1	pH	6.19	.	silt	48.7	.	
		1	C	5.18	.	clay	11.0	.	
	5 - 15	1	EC	0.55	.	sand	39.4	.	loam
		1	pH	6.59	.	silt	39.6	.	
		1	C	1.73	.	clay	21.0	.	
	15 - 30	1	EC	1.35	.	sand	40.6	.	loam
		1	pH	7.99	.	silt	34.6	.	
		1	C	1.00	.	clay	24.8	.	
	30 - 45	1	EC	1.28	.	sand	41.3	.	loam
		1	pH	8.34	.	silt	34.1	.	
		1	C	1.85	.	clay	24.7	.	
Spoil	0 - 5	3	EC	4.42	0.48	sand	39.2	13.8	loam
		3	pH	7.24	0.15	silt	45.5	14.0	
		3	C	4.20	0.78	clay	15.3	0.6	
Trench	0 - 5	3	EC	3.40	0.82	sand	40.6	5.0	loam
		3	pH	7.22	0.45	silt	38.1	4.7	
		3	C	2.74	0.46	clay	21.4	0.5	
Work	0 - 5	3	EC	3.27	0.87	sand	36.2	14.6	loam
		3	pH	6.60	0.21	silt	51.0	15.3	
		3	C	4.97	0.80	clay	12.8	1.5	

EC: electrical conductivity (mS/cm)
C: total carbon (%)
SD: standard deviation

Table A.18. Jenner South no-strip/no-seed penetration resistance, surface soil moisture and surface bulk density.

	Penetration Resistance (MPa)				Surface Moisture (%)			Surface Bulk Density (Mg m^{-3})	
Right-of-Way Zone	Depth (cm)	n	Mean	SD	n	Mean	SD	Mean	SD
Undisturbed prairie	0	30	0.7	0.3	15	9.7	2.0	1.05	0.08
	2.5	30	1.5	0.5					
	5.0	30	2.4	1.0					
	7.5	30	3.9	1.1					
	10.0	30	4.8	0.8					
	12.5	30	4.9	0.8					
	15.0	30	5.0	0.7					
	20.0	30	5.1	0.7					
Spoil	0	30	0.7	0.4	15	13.9	3.0	1.19	0.08
	2.5	30	1.8	0.6					
	5.0	30	3.0	1.0					
	7.5	30	4.6	1.0					
	10.0	30	5.0	0.7					
	12.5	30	5.2	0.7					
	15.0	30	5.2	0.6					
	20.0	30	5.2	0.7					
Trench	0	30	0.6	0.2	15	21.4	2.4	1.47	0.08
	2.5	30	1.5	0.4					
	5.0	30	2.2	0.8					
	7.5	30	2.6	0.9					
	10.0	30	2.8	1.0					
	12.5	30	2.9	1.2					
	15.0	30	2.8	1.2					
	20.0	30	3.0	1.2					
Work	0	30	0.8	0.4	15	16.6	3.0	1.24	0.15
	2.5	30	2.2	1.1					
	5.0	30	3.2	1.2					
	7.5	30	4.7	0.9					
	10.0	30	5.1	0.8					
	12.5	30	5.2	0.7					
	15.0	30	5.2	0.6					
	20.0	30	5.2	0.5					

SD: standard deviation

Table A.19. Jenner South no-strip/seed soil chemical and particle size distribution properties.

			Chemical Property			Particle Size Distribution			
Right-of-Way Zone	Depth (cm)	n	Chemical parameter	Mean	SD	Fraction	Mean	SD	Texture Class
Undisturbed prairie	0 - 5	1	EC	3.05	.	sand	41.1	.	loam
		1	pH	5.88	.	silt	47.0	.	
		1	C	5.35	.	clay	11.9	.	
	5 - 15	1	EC	1.05	.	sand	45.7	.	loam
		1	pH	6.39	.	silt	34.1	.	
		1	C	1.68	.	clay	20.2	.	
	15 - 30	1	EC	2.40	.	sand	42.7	.	clay loam
		1	pH	8.14	.	silt	27.0	.	
		1	C	1.00	.	clay	30.4	.	
	30 - 45	1	EC	8.00	.	sand	35.1	.	clay loam
		1	pH	8.06	.	silt	30.5	.	
		1	C	1.60	.	clay	34.4	.	
Spoil	0 - 5	3	EC	2.77	0.31	sand	37.6	0.7	loam
		3	pH	7.27	0.40	silt	48.9	0.5	silt loam
		3	C	4.69	0.55	clay	13.5	1.2	
Trench	0 - 5	3	EC	7.83	0.50	sand	41.2	1.4	loam
		3	pH	7.73	0.02	silt	36.8	2.0	
		3	C	2.12	0.31	clay	22.1	0.7	
Work	0 - 5	3	EC	5.17	1.60	sand	39.8	2.5	loam
		3	pH	7.02	0.71	silt	46.4	1.3	
		3	C	4.70	1.92	clay	13.8	1.2	

EC: electrical conductivity (mS/m)
C: total carbon (%)
SD: standard deviation

Table A.20. Jenner South no-strip/seed penetration resistance, surface soil moisture and surface bulk density.

	Penetration Resistance (MPa)				Surface Moisture (%)			Surface Bulk Density (Mg m^{-3})	
Right-of-Way Zone	Depth (cm)	n	Mean	SD	n	Mean	SD	Mean	SD
Undisturbed prairie	0	30	0.5	0.3	15	10.7	1..7	1.01	0.10
	2.5	30	1.4	0.4					
	5.0	30	2.3	0.9					
	7.5	30	4.1	0.9					
	10.0	30	4.8	0.9					
	12.5	30	4.9	0.9					
	15.0	30	5.1	0.7					
	20.0	30	5.2	0.6					
Spoil	0	30	0.6	0.4	15	16.5	3.9	1.12	0.11
	2.5	30	1.6	0.5					
	5.0	30	2.8	0.9					
	7.5	30	4.9	0.9					
	10.0	30	5.2	0.6					
	12.5	30	5.3	0.5					
	15.0	30	5.3	0.4					
	20.0	30	5.3	0.6					
Trench	0	30	0.6	0.3	15	22.4	2.8	1.48	0.12
	2.5	30	1.4	0.5					
	5.0	30	2.1	0.5					
	7.5	30	2.7	0.6					
	10.0	30	2.8	0.8					
	12.5	30	2.7	1.0					
	15.0	30	2.7	1.0					
	20.0	30	2.7	1.0					
Work	0	30	0.6	0.3	15	18.0	4.3	1.20	0.18
	2.5	30	1.8	0.6					
	5.0	30	3.4	1.1					
	7.5	30	4.9	1.0					
	10.0	30	5.0	0.9					
	12.5	30	5.0	0.9					
	15.0	30	5.1	0.8					
	20.0	30	5.0	1.0					

SD: standard deviation

Table A.21. Jenner South strip/no-seed soil chemical and particle size distribution properties.

			Chemical Property			Particle Size Distribution			
Right-of-Way Zone	Depth (cm)	n	Chemical parameter	Mean	SD	Fraction	Mean	SD	Texture Class
Undisturbed prairie	0 - 5	1	EC	6.50	.	sand	34.8	.	silt loam
		1	pH	6.13	.	silt	53.9	.	
		1	C	7.00	.	clay	11.3	.	
	5 - 15	1	EC	0.80	.	sand	41.3	.	loam
		1	pH	6.57	.	silt	43.3	.	
		1	C	2.39	.	clay	15.4	.	
	15 - 30	1	EC	0.60	.	sand	50.2	.	loam
		1	pH	6.99	.	silt	34.7	.	
		1	C	1.22	.	clay	15.2	.	
	30 - 45	1	EC	0.55	.	sand	44.7	.	loam
		1	pH	6.84	.	silt	36.3	.	
		1	C	0.84	.	clay	18.9	.	
Spoil	0 - 5	3	EC	3.67	1.92	sand	35.8	1.4	silt loam
		3	pH	6.92	0.30	silt	50.9	2.6	
		3	C	4.43	0.51	clay	13.3	1.4	
Trench	0 - 5	3	EC	5.57	0.70	sand	39.2	1.2	loam
		3	pH	7.65	0.03	silt	40.4	3.5	
		3	C	2.11	0.34	clay	20.4	2.4	
Work	0 - 5	3	EC	3.17	1.11	sand	34.1	0.8	loam
		3	pH	6.87	0.43	silt	47.3	1.7	
		3	C	2.92	0.45	clay	18.6	2.2	

EC: electrical conductivity (mS/cm)
C: total carbon (%)
SD: standard deviation

Table A.22. Jenner South strip/no-seed penetration resistance, surface soil moisture and surface bulk density.

	Penetration Resistance (MPa)					Surface Moisture (%)		Surface Bulk Density (Mg m^{-3})	
Right-of-Way Zone	Depth (cm)	n	Mean	SD	n	Mean	SD	Mean	SD
Undisturbed prairie	0	30	0.9	0.3	15	9.1	1.8	0.97	0.06
	2.5	30	1.5	0.5					
	5.0	30	2.3	0.8					
	7.5	30	3.7	1.1					
	10.0	30	4.5	1.0					
	12.5	30	4.9	0.8					
	15.0	30	5.0	0.9					
	20.0	30	5.0	0.8					
Spoil	0	30	0.9	0.3	15	11.3	3.7	1.09	1.14
	2.5	30	1.9	0.6					
	5.0	30	3.0	1.0					
	7.5	30	4.5	1.0					
	10.0	30	5.1	0.6					
	12.5	30	5.2	0.6					
	15.0	30	5.2	0.6					
	20.0	30	5.2	0.6					
Trench	0	30	0.5	0.3	15	16.8	2.3	1.43	0.18
	2.5	30	1.7	0.8					
	5.0	30	2.5	0.9					
	7.5	30	2.9	1.1					
	10.0	30	2.8	1.0					
	12.5	30	2.9	1.0					
	15.0	30	2.7	1.2					
	20.0	30	2.8	1.3					
Work	0	30	0.7	0.3	15	20.3	3.6	1.23	0.13
	2.5	30	1.9	0.8					
	5.0	30	2.1	0.9					
	7.5	30	2.4	1.1					
	10.0	30	2.7	1.1					
	12.5	30	2.7	1.1					
	15.0	30	2.7	1.1					
	20.0	30	2.8	1.2					

SD: standard deviation

Table A.23. Jenner South strip/seed soil chemical and particle size distribution properties.

			Chemical Property			Particle Size Distribution			
Right-of-Way Zone	Depth (cm)	n	Chemical parameter	Mean	SD	Fraction	Mean	SD	Texture Class
Undisturbed prairie	0 - 5	1	EC	1.60	.	sand	32.3	.	silt loam
		1	pH	6.41	.	silt	56.6	.	
		1	C	7.21	.	clay	11.1	.	
	5 - 15	1	EC	0.60	.	sand	33.5	.	loam
		1	pH	6.50	.	silt	49.7	.	silt loam
		1	C	2.70	.	clay	16.8	.	
	15 - 30	1	EC	0.45	.	sand	42.8	.	loam
		1	pH	6.74	.	silt	38.6	.	
		1	C	1.02	.	clay	18.5	.	
	30 - 45	1	EC	0.50	.	sand	41.3	.	loam
		1	pH	6.75	.	silt	37.0	.	
		1	C	0.85	.	clay	21.8	.	
Spoil	0 - 5	3	EC	4.10	0.85	sand	37.7	4.1	loam
		3	pH	7.03	0.44	silt	46.6	8..9	
		3	C	4.81	2.02	clay	15.7	4.7	
Trench	0 - 5	3	EC	3.40	0.82	sand	37.0	1.6	loam
		3	pH	7.22	0.45	silt	44.4	0.9	
		3	C	2.74	0.46	clay	18.6	0.8	
Work	0 - 5	3	EC	2.73	0.64	sand	36.2	2.5	loam
		3	pH	6.70	0.16	silt	43.8	3.1	
		3	C	2.65	0.32	clay	20.0	0.6	

EC: electrical conductivity (mS/cm)
C: total carbon (%)
SD: standard deviation

Table A.24. Jenner South strip/seed penetration resistance, surface soil moisture and surface bulk density.

	Penetration Resistance (MPa)				Surface Moisture (%)			Surface Bulk Density (Mg m^{-3})	
Right-of-Way Zone	Depth (cm)	n	Mean	SD	n	Mean	SD	Mean	SD
Undisturbed prairie	0	30	1.0	0.4	15	9.0	1.3	1.01	0.06
	2.5	30	1.6	0.4					
	5.0	30	2.3	0.5					
	7.5	30	3.5	0.8					
	10.0	30	4.6	0.8					
	12.5	30	4.7	0.9					
	15.0	30	5.0	0.8					
	20.0	30	5.0	0.8					
Spoil	0	30	0.8	0.5	15	13.2	4.1	1.12	0.08
	2.5	30	1.6	0.5					
	5.0	30	2.3	0.9					
	7.5	30	3.8	1.5					
	10.0	30	4.2	1.5					
	12.5	30	4.4	1.5					
	15.0	30	4.6	1.4					
	20.0	30	4.8	1.2					
Trench	0	30	0.4	0.3	15	19.3	2.2	1.38	0.14
	2.5	30	1.6	0.6					
	5.0	30	2.3	0.7					
	7.5	30	2.5	0.8					
	10.0	30	2.7	0.8					
	12.5	30	2.6	0.8					
	15.0	30	2.5	0.9					
	20.0	30	2.7	1.2					
Work	0	30	0.7	0.4	15	18.4	2.5	1.25	0.14
	2.5	30	2.0	0.9					
	5.0	30	2.4	0.9					
	7.5	30	2.6	1.0					
	10.0	30	2.8	1.0					
	12.5	30	2.9	0.8					
	15.0	30	2.9	0.7					
	20.0	30	3.0	0.8					

SD: standard deviation

APPENDIX B

SITE VEGETATION CHARACTERISTICS

Table B.1. Plant density (number of plants 0.1 m^{-2}) by year, treatment and right-of-way zone at the sod salvage research sites in 1997 and 1998.

Treatment		Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12
Undisturbed prairie	1	50.7	22.5												
1997 Seeded spoil	2	16.2	17.2	**											
1997 Seeded trench	3	7.1	3.8	**	**										
1997 Seeded work	4	7.8	10.6	**	**	N									
1997 Sodded spoil	5	22.3	20.4	**	**	**	**								
1997 Sodded trench	6	15.6	9.0	**	N	**	**	**							
1997 Sodded work	7	18.9	15.5	**	N	**	**	N	N						
1998 Seeded spoil	8	14.3	10.5	**	N	**	**	**	N	N					
1998 Seeded trench	9	9.9	7.9	**	**	N	N	**	**	**	N				
1998 Seeded work	10	9.8	8.1	**	**	N	N	**	**	**	N	N			
1998 Sodded spoil	11	22.6	16.2	**	**	**	**	N	**	N	**	**	**		
1998 Sodded trench	12	20.8	14.3	**	N	**	**	N	**	N	**	**	**	N	
1998 Sodded work	13	17.1	14.2	**	N	**	**	**	N	N	N	**	**	**	N

n = 70 except on undisturbed prairie where n = 150
** indicates significant at $p \leq 0.05$
N indicates not significant at $p \leq 0.05$

Table B.2. Species richness (number of species 0.1 m^{-2}) by year, treatment and zone at the sod salvage research sites in 1997 and 1998.

Treatment		Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1997 Undisturbed prairie	1	6.9	2.2															
1997 Seeded spoil	2	5.2	2.7	**														
1997 Seeded trench	3	3.1	1.8	**	**													
1997 Seeded work	4	3.3	2.5	**	**	N												
1997 Undisturbed prairie	5	6.9	2.2	N	**	**	**											
1997 Sodded spoil	6	5.0	2.4	**	N	**	**	**										
1997 Sodded trench	7	5.1	2.2	**	N	**	**	**	N									
1997 Sodded work	8	4.9	2.6	**	N	**	**	**	N	N								
1998 Undisturbed prairie	9	6.7	2.1	N	**	**	**	N	**	**	**							
1998 Seeded spoil	10	5.5	2.4	**	N	**	**	**	N	N	N	**						
1998 Seeded trench	11	3.8	1.8	**	**	**	N	**	**	**	**	**	**					
1998 Seeded work	12	4.3	2.3	**	**	**	**	**	N	**	N	**	**	N				
1998 Undisturbed prairie	13	6.7	2.1	N	**	**	**	N	**	**	**	N	**	**	**			
1998 Sodded spoil	14	5.7	2.7	**	N	**	**	**	N	N	**	**	N	**	**	**		
1998 Sodded trench	15	4.9	2.0	**	N	**	**	**	N	N	N	**	N	**	N	**	**	
1998 Sodded work	16	5.0	2.3	**	N	**	**	**	N	N	N	**	N	**	**	**	N	N

n = 70 except on undisturbed prairie where n = 60
** indicates significant at $p \leq 0.05$
N indicates not significant at $p \leq 0.05$

Table B.3. Live vegetation ground cover (%) excluding *Selaginella densa* by year, treatment and zone at the sod salvage research sites in 1997 and 1998.

Treatment		N	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1997 Undisturbed prairie	1	60	9.0	4.6															
1997 Seeded spoil	2	69	2.9	6.4	**														
1997 Seeded trench	3	70	0.4	0.6	**	**													
1997 Seeded work	4	70	0.8	1.7	**	**	N												
1997 Undisturbed prairie	5	60	9.0	4.6	N	**	**	**											
1997 Sodded spoil	6	66	3.2	3.4	**	N	**	**	**										
1997 Sodded trench	7	70	3.0	6.2	**	N	**	**	**	N									
1997 Sodded work	8	70	2.3	5.7	**	N	**	N	**	N	N								
1998 Undisturbed prairie	9	60	8.7	5.4	N	**	**	**	N	**	**	**							
1998 Seeded spoil	10	68	7.2	4.2	N	**	**	**	**	**	**	**	N						
1998 Seeded trench	11	70	6.9	3.9	**	**	**	**	**	**	**	**	**	N					
1998 Seeded work	12	70	5.7	3.7	**	**	**	**	**	**	**	**	**	N	N				
1998 Undisturbed prairie	13	60	8.7	5.4	N	**	**	**	N	**	**	**	N	N	**	**			
1998 Sodded spoil	14	70	7.3	4.3	N	**	**	**	**	**	**	**	N	N	N	**	N		
1998 Sodded trench	15	68	8.1	5.2	N	**	**	**	N	**	**	**	N	N	N	**	N	N	
1998 Sodded work	16	70	8.1	5.2	N	**	**	**	N	**	**	**	N	N	N	**	N	N	N

** indicates significant at p≤ 0.05
N indicates not significant at p≤ 0.05

Table B.4. Bare ground (%) by year, treatment and zone at the sod salvage research sites in 1997 and 1998.

Treatment		N	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1997 Undisturbed prairie	1	60	1.2	4.5															
1997 Seeded spoil	2	70	94.3	7.2	**														
1997 Seeded trench	3	69	97.2	3.2	**	N													
1997 Seeded work	4	70	96.4	4.6	**	N	N												
1997 Undisturbed prairie	5	60	1.5	4.6	N	**	**	**											
1997 Sodded spoil	6	66	84.9	23.3	**	**	**	**	**										
1997 Sodded trench	7	70	81.4	22.6	**	**	**	**	**	N									
1997 Sodded work	8	70	93.3	11.6	**	N	N	N	**	**	**								
1998 Undisturbed prairie	9	60	10.9	24.2	**	**	**	**	**	**	**	**							
1998 Seeded spoil	10	68	81.5	16.5	**	**	**	**	**	N	N	**	**						
1998 Seeded trench	11	70	69.9	28.7	**	**	**	**	**	**	**	**	**	**					
1998 Seeded work	12	70	84.1	18.8	**	**	**	**	**	N	N	**	**	N	**				
1998 Undisturbed prairie	13	60	10.9	24.2	**	**	**	**	**	**	**	**	N	**	**	**			
2998 Sodded spoil	14	70	80.5	20.1	**	**	**	**	**	N	N	**	**	N	**	N	**		
1998 Sodded trench	15	68	78.0	21.3	**	**	**	**	**	**	N	**	**	N	**	**	**	N	
1998 Sodded work	16	70	87.6	8.4	**	**	**	**	**	N	**	**	**	**	**	N	**	**	**

** indicates significant at p≤ 0.05
N indicates not significant at p≤ 0.05

Table B.5. Mean plant species density per 0.1 meter square on undisturbed prairie in 1997 and 1998 at the Hardisty site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	0.067	0.254	0.000	0.000
Agropyron smithii	1.333	2.682	0.033	0.183
Agrostis scabra	0.100	0.305	0.067	0.365
Agropyron subsecundum	3.700	6.347	1.267	2.180
Agropyron trachycaulum	0.000	0.000	0.567	1.716
Bouteloua gracilis	0.467	1.570	0.033	0.183
Bromus ciliatus	0.000	0.000	0.633	1.771
Bromus inermis	0.000	0.000	0.067	0.365
Carex species	13.633	15.248	21.467	17.463
Danthonia spicatum	0.467	1.737	0.000	0.000
Festuca hallii	19.133	16.021	3.367	4.047
Koeleria macrantha	0.167	0.747	0.167	0.592
Poa palustris	0.100	0.548	0.000	0.000
Poa pratensis/compressa	15.900	32.014	6.833	10.343
Stipa comata	0.333	0.959	0.000	0.000
Stipa curtiseta	0.933	1.617	0.233	0.626
Achillea millefolium	2.967	4.406	3.633	4.295
Agoseris glauca	0.000	0.000	0.067	0.254
Anenome cylindrica	0.067	0.254	0.000	0.000
Anenome patens	0.000	0.000	0.033	0.183
Antennaria species	0.767	3.148	0.300	0.915
Antennaria parvifolia	3.867	8.974	0.367	1.066
Artemisia frigida	0.100	0.548	0.033	0.183
Artemisia ludoviciana	3.133	4.790	2.700	4.757
Aster ciliolatus	0.067	0.365	0.000	0.000
Aster ericoides	0.000	0.000	0.133	0.730
Aster laevis	0.867	1.871	0.167	0.461
Astragalus striatus	0.000	0.000	0.067	0.254
Campanula rotundifolia	0.100	0.403	0.767	1.675
Cerastium arvense	0.300	1.208	0.000	0.000
Cirsium vulgare	0.033	0.183	0.033	0.183
Collomia linearis	0.200	1.095	0.000	0.000
Comandra umbellata	0.433	1.251	0.467	1.074
Erigeron species	0.167	0.747	0.000	0.000
Fragaria virginiana	0.000	0.000	0.167	0.913
Galium boreale	0.033	0.183	0.067	0.365
Geum triflorum	0.000	0.000	0.033	0.183
Hedysarum alpinum	0.000	0.000	0.033	0.183
Helianthus species	0.000	0.000	0.033	0.183
Lathyrus species	0.000	0.000	0.033	0.183
Monarda fistulosa	0.067	0.254	0.000	0.000

Penstemon species	0.067	0.365	0.000	0.000
Potentilla anserina	0.033	0.183	0.000	0.000
Potentilla gracilis	0.000	0.000	0.400	1.850
Potentilla norvegica	0.000	0.000	0.167	0.648
Psoralea species	0.000	0.000	0.100	0.403
Psoralea argophylla	0.033	0.183	0.000	0.000
Rosa species	0.633	1.884	0.633	1.159
Sisyrinchium montanum	0.033	0.183	0.000	0.000
Solidago canadensis	4.000	8.317	0.133	0.730
Solidago missouriensis	1.000	3.620	2.967	3.837
Solidago rigida	0.267	0.785	0.000	0.000
Sonchus species	0.033	0.183	0.067	0.365
Symphoricarpos albus	0.033	0.183	0.000	0.000
Symphoricarpos occidentalis	0.367	1.033	0.133	0.571
Taraxacum officinale	0.000	0.000	0.200	0.761
Vicia americana	1.533	4.659	0.467	1.008
Viola adunca	0.033	0.183	0.000	0.000
Viola species	0.267	0.828	0.267	0.980

n = 30

Table B.6. Mean plant species density per 0.1 meter square on the seeded spoil zone in 1997 and 1998 at the Hardisty site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron species	0.067	0.254	0.000	0.000
Agropyron dasystachyum	1.133	1.383	0.667	1.061
Agropyron riparium	0.267	0.691	0.000	0.000
Agropyron smithii	0.700	0.877	0.100	0.305
Agrostis scabra	0.000	0.000	0.267	0.785
Agropyron subsecundum	0.167	0.461	0.267	0.640
Agropyron trachycaulum	0.867	1.167	1.633	3.672
Bouteloua gracilis	0.667	2.591	0.000	0.000
Bromus ciliatus	0.000	0.000	0.067	0.254
Bromus inermis	0.000	0.000	0.100	0.305
Carex species	1.467	4.629	0.000	0.000
Dactylis glomerata	0.000	0.000	0.033	0.183
Festuca species	3.533	3.048	0.000	0.000
Festuca hallii	0.567	2.596	0.233	0.430
Festuca idahoensis	0.200	0.761	0.000	0.000
Festuca ovina	0.033	0.183	2.433	2.674
Helictrotrichon hookeri	0.133	0.571	0.033	0.183
Koeleria macrantha	0.133	0.346	0.567	0.817
Poa palustris	0.000	0.000	0.200	0.610
Poa pratensis/compressa	0.767	3.830	0.267	0.640
Stipa curtiseta	0.200	0.925	0.000	0.000
Stipa viridula	0.067	0.365	0.200	0.484
Achillea millefolium	0.433	1.331	0.133	0.571
Ambrosia species	0.000	0.000	0.033	0.183
Anenome species	0.033	0.183	0.000	0.000
Antennaria parvifolia	0.800	4.382	0.000	0.000
Artemisia ludoviciana	0.033	0.183	0.000	0.000
Aster ericoides	0.000	0.000	0.033	0.183
Aster laevis	0.167	0.913	0.000	0.000
Astragalus species	0.300	1.466	0.033	0.183
Campanula rotundifolia	0.067	0.254	0.000	0.000
Capsella bursa-pastoris	0.100	0.305	0.000	0.000
Chenopodium album	0.133	0.346	0.533	2.374
Cirsium arvense	0.033	0.183	0.133	0.434
Collomia linearis	0.000	0.000	0.033	0.183
Comandra umbellata	0.267	1.143	0.000	0.000
Crepis tectorum	0.167	0.379	0.033	0.183
Descurainia sophia	0.000	0.000	0.100	0.403
Draba species	0.067	0.254	0.000	0.000
Geranium bicknellii	0.100	0.305	0.000	0.000
Geum species	0.033	0.183	0.000	0.000

Geum triflorum	0.100	0.548	0.000	0.000
Hedysarum alpinum	0.000	0.000	0.033	0.183
Glechoma hederacea	0.033	0.183	0.000	0.000
Lactuca pulchella	0.000	0.000	0.033	0.183
Lathyrus species	0.100	0.305	0.167	0.379
Monarda fistulosa	0.367	2.008	0.000	0.000
Oxytropis sericea	0.067	0.254	0.000	0.000
Penstemon species	0.433	1.775	0.000	0.000
Polygonum aviculare	0.000	0.000	0.133	0.434
Polygonum convulvulus	0.033	0.183	0.133	0.434
Populus tremuloides	0.033	0.183	0.000	0.000
Potentilla species	0.033	0.183	0.000	0.000
Potentilla norvegica	0.000	0.000	0.100	0.305
Psoralea argophylla	0.033	0.183	0.000	0.000
Rosa species	0.033	0.183	0.067	0.254
Sonchus species	0.033	0.183	0.000	0.000
Symphoricarpos albus	0.133	0.434	0.000	0.000
Taraxacum officinale	0.200	0.407	0.800	1.243
Thermopsis rhombifolia	0.200	1.095	0.000	0.000
Thlaspi arvense	0.233	0.679	0.000	0.000
Thalictrum occidentale/venulosa	0.000	0.000	0.267	1.112
Urtica dioica	0.000	0.000	0.033	0.183
Vicia americana	0.400	0.770	0.167	0.461
Viola species	0.100	0.403	0.000	0.000
Viola adunca	0.000	0.000	0.067	0.365
Weed seedling	0.100	0.305	4.733	8.337

n = 30

Table B.7. Mean plant species density per 0.1 meter square on the seeded trench zone in 1997 and 1998 at the Hardisty site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron species	0.033	0.183	0.067	0.254
Agropyron dasystachyum	0.467	0.730	0.233	0.568
Agropyron repens	0.033	0.183	0.000	0.000
Agropyron riparium	0.167	0.461	0.000	0.000
Agropyron smithii	0.267	0.521	0.000	0.000
Agrostis scabra	0.000	0.000	0.133	0.346
Agropyron subsecundum	0.100	0.305	0.167	0.461
Agropyron trachycaulum	0.933	1.530	0.700	1.088
Bromus inermis	0.000	0.000	0.300	1.466
Carex species	0.267	0.521	0.067	0.254
Festuca species	0.967	1.752	0.000	0.000
Festuca hallii	0.100	0.403	0.033	0.183
Festuca ovina	0.000	0.000	0.533	0.681
Helictrotrichon hookeri	0.033	0.183	0.000	0.000
Hordeum jubatum	0.033	0.183	0.033	0.183
Koeleria macrantha	0.400	0.855	0.033	0.183
Poa pratensis/compressa	0.167	0.592	0.233	0.568
Stipa viridula	0.100	0.403	0.033	0.183
Achillea millefolium	0.033	0.183	0.267	0.980
Ambrosia species	0.000	0.000	0.067	0.365
Aster ericoides	0.000	0.000	0.067	0.254
Aster laevis	0.033	0.183	0.133	0.434
Chenopodium album	0.000	0.000	0.033	0.183
Cirsium arvense	0.033	0.183	0.233	0.626
Collomia linearis	0.000	0.000	0.033	0.183
Crepis tectorum	0.133	0.434	0.100	0.305
Draba species	0.167	0.461	0.000	0.000
Epilobium species	0.000	0.000	0.033	0.183
Geranium bicknellii	0.100	0.305	0.000	0.000
Geum species	0.000	0.000	0.000	0.000
Geum macrophyllum	0.000	0.000	0.033	0.183
Geum triflorum	0.033	0.183	0.000	0.000
Hedysarum alpinum	0.000	0.000	0.133	0.346
Lactuca pulchella	0.033	0.183	0.000	0.000
Lathyrus species	0.000	0.000	0.167	0.592
Lepidium densiflorum	0.000	0.000	0.067	0.365
Plantago species	0.033	0.183	0.000	0.000
Plantago major	0.000	0.000	0.100	0.305
Polygonum aviculare	0.000	0.000	0.200	0.407
Polygonum convulvulus	0.067	0.254	0.167	0.531
Rosa species	0.067	0.254	0.033	0.183

Rubus idaeus	0.000	0.000	0.033	0.183
Solidago rigida	0.000	0.000	0.033	0.183
Sonchus species	0.033	0.183	0.033	0.183
Stachys palustris	0.033	0.183	0.000	0.000
Symphoricarpos albus	0.067	0.254	0.000	0.000
Symphoricarpos occidentalis	0.167	0.461	0.233	0.626
Taraxacum officinale	0.267	0.521	0.433	1.135
Thermopsis rhombifolia	0.033	0.183	0.033	0.183
Thlaspi arvense	0.100	0.305	0.067	0.254
Vicia americana	0.533	0.776	0.167	0.747
Viola species	0.033	0.183	0.000	0.000
Weed seedling	0.067	0.254	4.833	9.094

n = 30

Table B.8. Mean plant species density per 0.1 meter square on the seeded work zone in 1997 and 1998 at the Hardisty site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron species	0.000	0.000	0.100	0.305
Agropyron dasystachyum	0.733	0.944	0.200	0.484
Agropyron riparium	0.033	0.183	0.000	0.000
Agropyron smithii	0.400	0.675	0.100	0.305
Agrostis scabra	0.100	0.403	0.767	3.645
Agropyron subsecundum	0.000	0.000	0.200	0.551
Agropyron trachycaulum	0.733	1.112	0.800	1.064
Bromus inermis	0.033	0.183	0.033	0.183
Carex species	0.300	0.794	0.033	0.183
Dactylis glomerata	0.000	0.000	0.033	0.183
Festuca species	1.933	3.129	0.000	0.000
Festuca hallii	0.000	0.000	0.100	0.403
Festuca ovina	0.000	0.000	1.200	1.495
Grass seedling	0.067	0.365	0.000	0.000
Helictrotrichon hookeri	0.267	0.828	0.000	0.000
Koeleria macrantha	0.100	0.403	0.200	0.551
Poa species	0.000	0.000	0.033	0.183
Poa palustris	0.000	0.000	0.033	0.183
Poa pratensis/compressa	0.067	0.254	0.133	0.346
Stipa viridula	0.067	0.365	0.167	0.379
Achillea millefolium	0.033	0.183	0.033	0.183
Aster species	0.100	0.305	0.000	0.000
Aster ciliolatus	0.033	0.183	0.000	0.000
Aster laevis	0.067	0.365	0.000	0.000
Chenopodium species	0.000	0.000	0.033	0.183
Chenopodium album	0.000	0.000	0.100	0.305
Cirsium arvense	0.033	0.183	0.100	0.305
Crepis tectorum	0.133	0.434	0.300	1.291
Descurainia sophia	0.000	0.000	0.033	0.183
Geranium species	0.033	0.183	0.033	0.183
Geranium bicknellii	0.167	0.531	0.000	0.000
Hedysarum alpinum	0.000	0.000	0.133	0.434
Lathyrus species	0.033	0.183	0.067	0.254
Lepidium densiflorum	0.000	0.000	0.067	0.254
Medicago sativa	0.033	0.183	0.033	0.183
Plantago species	0.033	0.183	0.000	0.000
Plantago major	0.033	0.183	0.000	0.000
Polygonum aviculare	0.000	0.000	0.033	0.183
Polygonum convulvulus	0.033	0.183	0.100	0.305
Polygonum species	0.000	0.000	0.033	0.183
Potentilla norvegica	0.000	0.000	0.033	0.183

Rosa species	0.067	0.254	0.033	0.183
Rubus idaeus	0.000	0.000	0.033	0.183
Solidago canadensis	0.000	0.000	0.133	0.571
Sonchus species	0.033	0.183	0.000	0.000
Symphoricarpos occidentalis	0.067	0.254	0.167	0.379
Taraxacum officinale	0.033	0.183	0.267	0.521
Thlaspi arvense	0.167	0.592	0.033	0.183
Vicia americana	0.333	0.547	0.033	0.183
Viola species	0.033	0.183	0.000	0.000
Weed seedling	0.000	0.000	0.033	0.183

n = 30

Table B.9. Mean plant species density per 0.1 meter square on the sodded spoil zone in 1997 and 1998 at the Hardisty site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	0.000	0.000	0.067	0.254
Agropyron smithii	0.233	0.626	0.067	0.365
Agrostis scabra	0.000	0.000	0.067	0.365
Agropyron subsecundum	1.300	2.395	1.300	2.423
Agropyron trachycaulum	0.167	0.531	0.167	0.592
Bouteloua gracilis	0.000	0.000	0.067	0.365
Bromus anomalus	0.033	0.183	0.000	0.000
Bromus inermis	0.533	1.479	0.767	1.736
Calamagrostis montanensis	0.000	0.000	0.033	0.183
Carex species	3.233	7.899	1.200	2.058
Festuca hallii	0.300	1.119	0.200	0.925
Festuca idahoensis	0.667	2.987	0.000	0.000
Helictrotrichon hookeri	0.033	0.183	0.000	0.000
Koeleria macrantha	0.000	0.000	0.100	0.548
Poa species	0.000	0.000	0.300	1.643
Poa palustris	0.000	0.000	0.067	0.365
Poa pratensis/compressa	3.500	4.501	3.467	4.703
Achillea millefolium	1.700	3.573	4.133	6.986
Agoseris glauca	0.033	0.183	0.000	0.000
Ambrosia species	0.000	0.000	0.200	0.664
Antennaria parvifolia	0.267	1.048	0.000	0.000
Artemisia biennis	0.000	0.000	0.033	0.183
Artemisia frigida	0.167	0.913	0.067	0.254
Artemisia ludoviciana	0.267	0.944	0.533	1.456
Aster conspicuus	0.267	0.944	0.000	0.000
Aster ericoides	0.067	0.365	0.400	1.522
Aster laevis	0.267	1.048	0.333	1.155
Astragalus species	0.000	0.000	0.033	0.183
Astragalus striatus	0.000	0.000	0.033	0.183
Campanula rotundifolia	0.000	0.000	0.300	1.317
Cerastium arvense	0.133	0.571	0.800	2.747
Chenopodium species	0.000	0.000	0.133	0.730
Chenopodium album	0.133	0.571	0.067	0.254
Cirsium vulgare	0.000	0.000	0.100	0.548
Collomia linearis	0.000	0.000	0.033	0.183
Comandra umbellata	0.467	1.167	0.500	1.592
Crepis tectorum	0.000	0.000	0.333	1.493
Descurainia sophia	0.000	0.000	0.067	0.365
Draba species	0.067	0.254	0.000	0.000
Fragaria virginiana	0.067	0.254	0.100	0.548
Galium boreale	0.600	1.694	0.433	1.478

Geranium bicknellii	0.067	0.254	0.000	0.000
Geum macrophyllum	0.000	0.000	0.033	0.183
Geum triflorum	0.000	0.000	0.000	0.000
Hedysarum alpinum	0.000	0.000	0.033	0.183
Helianthus species	0.000	0.000	0.033	0.183
Heuchera richardsonii	0.167	0.913	0.000	0.000
Lactuca pulchella	0.333	0.844	0.633	1.732
Lappula species	0.000	0.000	0.100	0.403
Lathyrus species	0.100	0.548	0.000	0.000
Lepidium densiflorum	0.000	0.000	0.200	0.551
Oxytropis species	0.000	0.000	0.067	0.365
Penstemon species	1.433	3.626	0.000	0.000
Plantago species	0.067	0.254	0.000	0.000
Polygonum aviculare	0.000	0.000	0.133	0.434
Polygonum convulvulus	0.000	0.000	3.900	4.604
Populus tremuloides	0.067	0.254	0.000	0.000
Potentilla norvegica	0.000	0.000	0.067	0.254
Psoralea argophylla	0.633	1.217	0.000	0.000
Rosa species	0.433	0.728	0.633	1.671
Solidago species	0.000	0.000	0.233	1.104
Solidago canadensis	0.467	1.776	0.100	0.548
Solidago missouriensis	0.000	0.000	0.500	1.306
Solidago rigida	0.367	2.008	0.300	1.643
Symphoricarpos occidentalis	0.733	1.721	0.133	0.730
Taraxacum officinale	0.133	0.346	1.867	4.400
Thermopsis rhombifolia	0.133	0.571	0.700	1.317
Thlaspi arvense	0.000	0.000	0.033	0.183
Tragopogon dubius	0.000	0.000	0.033	0.183
Urtica dioica	0.000	0.000	0.000	0.000
Vicia americana	0.767	1.478	0.133	0.346
Viola adunca	0.100	0.305	0.133	0.571
Weed seedling	0.000	0.000	2.167	5.760

n = 30

Table B.10. Mean plant species density per 0.1 meter square on the sodded trench zone in 1997 and 1998 at the Hardisty site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	0.000	0.000	0.133	0.571
Agropyron smithii	0.100	0.305	0.467	1.358
Agrostis scabra	0.067	0.254	0.033	0.183
Agropyron subsecundum	1.933	2.532	1.167	1.599
Agropyron trachycaulum	0.033	0.183	0.000	0.000
Bouteloua gracilis	0.000	0.000	0.100	0.403
Bromus anomalus	0.033	0.183	0.000	0.000
Bromus inermis	0.100	0.403	0.167	0.747
Calamagrostis montanensis	0.100	0.403	0.000	0.000
Carex species	3.500	5.290	1.300	3.415
Festuca hallii	0.533	0.973	0.000	0.000
Festuca idahoensis	0.067	0.365	0.000	0.000
Hordeum jubatum	0.000	0.000	0.033	0.183
Koeleria macrantha	0.033	0.183	0.067	0.365
Poa alpinum	0.033	0.183	0.000	0.000
Poa palustris	0.033	0.183	0.000	0.000
Poa pratensis/compressa	3.033	3.970	4.833	5.925
Stipa viridula	0.033	0.183	0.100	0.403
Achillea millefolium	1.267	1.680	3.300	5.615
Amaranthus retroflexus	0.033	0.183	0.000	0.000
Ambrosia species	0.000	0.000	0.600	1.714
Artemisia frigida	0.000	0.000	0.033	0.183
Artemisia ludoviciana	0.100	0.305	0.633	1.474
Aster ericoides	0.333	1.647	0.300	1.149
Aster laevis	0.400	1.163	0.200	0.610
Astragalus species	0.233	0.935	0.133	0.730
Campanula rotundifolia	0.033	0.183	0.033	0.183
Cerastium arvense	0.267	0.691	0.000	0.000
Chenopodium album	0.233	0.679	0.333	1.028
Cirsium arvense	0.000	0.000	0.033	0.183
Cirsium vulgare	0.033	0.183	0.000	0.000
Comandra umbellata	0.567	1.006	0.267	0.828
Crepis tectorum	0.033	0.183	0.000	0.000
Descurainia sophia	0.000	0.000	0.167	0.461
Galium boreale	0.000	0.000	0.200	0.664
Geranium bicknellii	0.033	0.183	0.000	0.000
Hedysarum alpinum	0.000	0.000	0.033	0.183
Lactuca pulchella	0.233	0.679	0.167	0.531
Lappula species	0.000	0.000	2.200	8.471
Lathyrus species	0.133	0.507	0.000	0.000
Lepidium densiflorum	0.000	0.000	0.900	2.426

Linnaea borealis	0.000	0.000	0.033	0.183
Sphaeralcea coccinea	0.000	0.000	0.033	0.183
Penstemon species	0.133	0.434	0.000	0.000
Plantago species	0.033	0.183	0.000	0.000
Polygonum aviculare	0.000	0.000	0.167	0.747
Polygonum convulvulus	0.133	0.346	4.133	5.450
Polygonum species	0.033	0.183	0.000	0.000
Potentilla norvegica	0.000	0.000	0.067	0.254
Psoralea species	0.033	0.183	0.000	0.000
Psoralea argophylla	0.200	0.407	0.000	0.000
Rosa species	0.267	0.640	0.267	0.691
Rubus idaeus	0.033	0.183	0.000	0.000
Salix species	0.000	0.000	0.100	0.548
Sisyrinchium monyanum	0.033	0.183	0.000	0.000
Solidago species	0.000	0.000	0.067	0.365
Solidago canadensis	0.267	1.461	0.067	0.365
Solidago missouriensis	0.000	0.000	0.833	2.019
Solidago rigida	0.067	0.365	0.367	1.497
Sonchus species	0.033	0.183	0.000	0.000
Stellaria species	0.067	0.254	0.000	0.000
Symphoricarpos albus	0.033	0.183	0.000	0.000
Symphoricarpos occidentalis	0.200	0.610	0.033	0.183
Taraxacum officinale	0.033	0.183	2.200	9.827
Thermopsis rhombifolia	0.033	0.183	0.167	0.461
Tragopogon dubius	0.033	0.183	0.000	0.000
Vicia americana	0.867	1.279	0.533	1.408
Viola species	0.033	0.183	0.000	0.000
Viola adunca	0.100	0.403	0.000	0.000
Weed seedling	0.000	0.000	0.100	0.403

n = 30

Table B.11. Mean plant species density per 0.1 meter square on the sodded work zone in 1997 and 1998 at the Hardisty site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	0.233	0.679	0.067	0.365
Agropyron smithii	0.367	0.928	0.633	1.810
Agropyron subsecundum	1.567	2.373	0.867	1.456
Agropyron trachycaulum	0.000	0.000	0.267	0.583
Bouteloua gracilis	0.000	0.000	0.100	0.403
Bromus ciliatus	0.000	0.000	0.033	0.183
Bromus inermis	0.000	0.000	0.133	0.346
Calamagrostis montanensis	0.100	0.305	0.000	0.000
Carex species	5.900	8.413	5.633	10.545
Festuca species	0.033	0.183	0.000	0.000
Festuca hallii	0.633	1.351	0.633	1.691
Helictrotrichon hookeri	0.033	0.183	0.000	0.000
Koeleria macrantha	0.033	0.183	0.067	0.254
Poa pratensis/compressa	6.000	9.396	5.133	7.152
Stipa curtiseta	0.000	0.000	0.200	0.664
Achillea millefolium	1.267	2.363	2.233	3.549
Agoseris glauca	0.067	0.365	0.000	0.000
Ambrosia species	0.000	0.000	0.100	0.548
Anenome species	0.000	0.000	0.033	0.183
Antennaria parvifolia	0.033	0.183	0.000	0.000
Artemisia frigida	0.033	0.183	0.067	0.254
Artemisia ludoviciana	0.167	0.461	0.167	0.461
Aster species	0.033	0.183	0.000	0.000
Aster ericoides	0.033	0.183	0.100	0.305
Aster laevis	1.367	4.429	0.067	0.254
Astragalus species	0.967	1.921	0.567	1.223
Campanula rotundifolia	0.000	0.000	0.033	0.183
Cerastium arvense	0.000	0.000	0.133	0.730
Chenopodium album	0.067	0.254	0.133	0.571
Cirsium arvense	0.067	0.365	0.000	0.000
Comandra umbellata	0.167	0.461	0.067	0.254
Crepis tectorum	0.033	0.183	0.000	0.000
Delphinium glauca	0.033	0.183	0.000	0.000
Descurainia sophia	0.000	0.000	0.133	0.434
Galium boreale	0.200	0.761	0.200	0.805
Geum species	0.033	0.183	0.000	0.000
Glechoma hederacea	0.067	0.254	0.000	0.000
Lactuca pulchella	0.800	2.091	0.467	1.167
Lathyrus species	0.000	0.000	0.133	0.730
Lepidium densiflorum	0.000	0.000	0.167	0.648
Sphaeralcea coccinea	0.000	0.000	0.033	0.183

Penstemon species	0.100	0.403	0.000	0.000
Polygonum aviculare	0.000	0.000	0.100	0.403
Polygonum convulvulus	0.000	0.000	0.933	2.766
Potentilla norvegica	0.000	0.000	0.067	0.365
Potemtilla gracilis	0.000	0.000	0.033	0.183
Potentilla anserina	0.033	0.183	0.000	0.000
Psoralea argophylla	0.067	0.365	0.000	0.000
Rosa species	0.333	0.959	0.233	0.728
Rubus idaeus	0.100	0.403	0.100	0.548
Solidago missouriensis	0.533	1.502	2.067	5.085
Symphoricarpos albus	0.033	0.183	0.000	0.000
Symphoricarpos occidentalis	1.033	2.356	0.833	1.821
Taraxacum officinale	0.167	0.592	0.500	1.548
Thermopsis rhombifolia	0.100	0.403	0.400	1.499
Tragopogon dubius	0.000	0.000	0.033	0.183
Vicia americana	1.100	1.447	0.667	1.241
Viola adunca	0.133	0.346	0.033	0.183
Weed seedling	0.000	0.000	0.133	0.730

n = 30

Table B.12. Mean percent ground cover by plant species on undisturbed prairie in 1997 and 1998 at the Hardisty site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	0.012	0.049	0.000	0.000
Agropyron smithii	0.118	0.282	0.007	0.037
Agrostis scabra	0.008	0.024	0.013	0.071
Agropyron subsecundum	0.439	0.694	0.366	0.592
Agropyron trachycaulum	0.000	0.000	0.107	0.261
Bouteloua gracilis	0.107	0.448	0.002	0.011
Bromus ciliatus	0.000	0.000	0.319	0.787
Bromus inermis	0.000	0.000	0.009	0.049
Carex species	1.193	1.600	1.969	1.568
Danthonia spicatum	0.032	0.112	0.000	0.000
Festuca hallii	3.363	2.490	0.950	0.812
Koeleria macrantha	0.022	0.110	0.036	0.120
Poa palustris	0.007	0.037	0.000	0.000
Poa pratensis/compressa	1.414	2.533	1.808	2.084
Stipa comata	0.019	0.068	0.000	0.000
Stipa curtiseta	0.166	0.338	0.151	0.401
Achillea millefolium	0.288	0.348	0.384	0.558
Agoseris glauca	0.000	0.000	0.016	0.063
Anenome cylindrica	0.006	0.023	0.000	0.000
Anenome patens	0.000	0.000	0.015	0.082
Antennaria species	0.084	0.333	0.033	0.089
Antennaria parvifolia	1.249	3.834	0.047	0.133
Artemisia frigida	0.011	0.058	0.005	0.029
Artemisia ludoviciana	0.253	0.508	0.320	0.587
Aster ciliolatus	0.007	0.038	0.000	0.000
Aster ericoides	0.000	0.000	0.040	0.219
Aster laevis	0.108	0.363	0.030	0.084
Astragalus striatus	0.000	0.000	0.004	0.017
Campanula rotundifolia	0.010	0.034	0.053	0.108
Cerastium arvense	0.023	0.086	0.000	0.000
Cirsium vulgare	0.010	0.055	0.065	0.356
Collomia linearis	0.005	0.027	0.000	0.000
Comandra umbellata	0.023	0.062	0.035	0.084
Erigeron species	0.027	0.108	0.000	0.000
Fragaria virginiana	0.000	0.000	0.008	0.044
Galium boreale	0.002	0.011	0.003	0.018
Geum triflorum	0.000	0.000	0.005	0.026
Hedysarum alpinum	0.000	0.000	0.002	0.011
Helianthus species	0.000	0.000	0.015	0.082
Lathyrus species	0.000	0.000	0.002	0.013
Monarda fistulosa	0.005	0.018	0.000	0.000

Penstemon species	0.009	0.051	0.000	0.000
Potentilla norvegica	0.000	0.000	0.006	0.023
Potemtilla gracilis	0.000	0.000	0.121	0.639
Potentilla anserina	0.003	0.015	0.000	0.000
Psoralea species	0.000	0.000	0.019	0.083
Psoralea argophylla	0.037	0.201	0.000	0.000
Rosa species	0.037	0.088	0.048	0.077
Sisyrinchium monyanum	0.003	0.016	0.000	0.000
Solidago canadensis	0.387	0.921	0.063	0.345
Solidago missouriensis	0.158	0.564	0.458	0.593
Solidago rigida	0.027	0.102	0.000	0.000
Sonchus species	0.003	0.015	0.019	0.102
Symphoricarpos albus	0.011	0.058	0.000	0.000
Symphoricarpos occidentalis	0.022	0.056	0.018	0.071
Taraxacum officinale	0.000	0.000	0.041	0.146
Vicia americana	0.084	0.294	0.028	0.059
Viola species	0.002	0.009	0.000	0.000
Viola adunca	0.010	0.033	0.025	0.078

n = 30

Table B.13. Mean percent ground cover by plant species on the seeded spoil zone in 1997 and 1998 at the Hardisty site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron species	0.002	0.011	0.000	0.000
Agropyron dasystachyum	0.083	0.151	0.336	0.694
Agropyron riparium	0.015	0.044	0.000	0.000
Agropyron smithii	0.032	0.054	0.084	0.293
Agrostis scabra	0.000	0.000	0.051	0.152
Agropyron subsecundum	0.010	0.031	0.320	0.812
Agropyron trachycaulum	0.044	0.079	0.897	1.357
Bouteloua gracilis	0.049	0.249	0.000	0.000
Bromus ciliatus	0.000	0.000	0.021	0.088
Bromus inermis	0.000	0.000	0.060	0.239
Carex species	0.193	0.628	0.000	0.000
Dactylis glomerata	0.000	0.000	0.227	1.220
Festuca species	0.034	0.052	0.000	0.000
Festuca hallii	0.223	1.098	0.100	0.200
Festuca idahoensis	0.025	0.124	0.000	0.000
Festuca ovina	0.001	0.007	1.831	1.979
Helictrotrichon hookeri	0.006	0.028	0.016	0.084
Koeleria macrantha	0.007	0.019	0.219	0.341
Poa palustris	0.270	1.458	0.129	0.457
Poa pratensis/compressa	0.000	0.000	0.042	0.127
Stipa curtiseta	0.030	0.134	0.000	0.000
Stipa viridula	0.001	0.004	0.212	0.726
Achillea millefolium	0.049	0.150	0.052	0.199
Ambrosia species	0.000	0.000	0.014	0.074
Anenome species	0.004	0.020	0.000	0.000
Antennaria parvifolia	0.328	1.797	0.000	0.000
Artemisia ludoviciana	0.002	0.011	0.000	0.000
Aster ericoides	0.000	0.000	0.023	0.123
Aster laevis	0.072	0.394	0.000	0.000
Astragalus species	0.013	0.063	0.001	0.007
Campanula rotundifolia	0.022	0.092	0.000	0.000
Capsella bursa-pastoris	0.123	0.491	0.000	0.000
Chenopodium album	0.057	0.214	0.013	0.045
Cirsium arvense	0.012	0.068	0.045	0.165
Collomia linearis	0.000	0.000	0.011	0.059
Comandra umbellata	0.035	0.133	0.000	0.000
Crepis tectorum	0.295	0.807	0.005	0.026
Descurainia sophia	0.000	0.000	0.011	0.043
Draba species	0.002	0.011	0.000	0.000
Geranium bicknellii	0.026	0.098	0.000	0.000
Geum species	0.003	0.015	0.000	0.000

Geum triflorum	0.020	0.110	0.000	0.000
Hedysarum alpinum	0.000	0.000	0.022	0.119
Glechoma hederacea	0.006	0.031	0.000	0.000
Lathyrus species	0.002	0.008	0.009	0.023
Monarda fistulosa	0.044	0.241	0.000	0.000
Oxytropis species	0.000	0.000	0.000	0.000
Oxytropis sericea	0.010	0.045	0.000	0.000
Penstemon species	0.059	0.281	0.000	0.000
Polygonum aviculare	0.000	0.000	0.036	0.126
Polygonum convulvulus	0.001	0.007	0.012	0.039
Populus tremuloides	0.001	0.004	0.000	0.000
Potentilla species	0.001	0.004	0.000	0.000
Potentilla norvegica	0.000	0.000	0.078	0.244
Psoralea argophylla	0.001	0.004	0.000	0.000
Rosa species	0.034	0.186	0.024	0.107
Sonchus species	0.125	0.686	0.000	0.000
Symphoricarpos albus	0.007	0.021	0.000	0.000
Taraxacum officinale	0.033	0.104	0.175	0.421
Thermopsis rhombifolia	0.024	0.131	0.000	0.000
Thlaspi arvense	0.059	0.306	0.000	0.000
Thalictrum occidentale/venul	0.000	0.000	0.011	0.034
Urtica dioica	0.000	0.000	0.005	0.026
Vicia americana	0.010	0.027	0.013	0.042
Viola species	0.028	0.108	0.000	0.000
Viola adunca	0.000	0.000	0.004	0.022
Weed seedling	0.009	0.044	0.028	0.048

n = 30 1997, n = 29 1998

Table B.14. Mean percent ground cover by plant species on the seeded trench zone in 1997 and 1998 at the Hardisty site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron species	0.000	0.002	0.189	0.782
Agropyron dasystachyum	0.026	0.048	0.486	1.486
Agropyron repens	0.000	0.002	0.000	0.000
Agropyron riparium	0.013	0.043	0.000	0.000
Agropyron smithii	0.008	0.018	0.000	0.000
Agrostis scabra	0.000	0.000	0.275	0.829
Agropyron subsecundum	0.017	0.071	0.623	1.823
Agropyron trachycaulum	0.058	0.101	1.329	2.041
Bromus inermis	0.000	0.000	0.059	0.239
Carex species	0.007	0.014	0.094	0.433
Festuca species	0.010	0.018	0.000	0.000
Festuca hallii	0.001	0.004	0.006	0.033
Festuca idahoensis	0.000	0.000	0.000	0.000
Festuca ovina	0.000	0.000	0.813	1.341
Helictrotrichon hookeri	0.002	0.009	0.000	0.000
Hordeum jubatum	0.001	0.007	0.012	0.066
Koeleria macrantha	0.007	0.017	0.025	0.137
Muhlenbergia cuspidata	0.000	0.000	0.132	0.721
Poa palustris	0.004	0.017	0.401	1.336
Stipa viridula	0.010	0.046	0.044	0.241
Achillea millefolium	0.000	0.002	0.028	0.105
Ambrosia species	0.000	0.000	0.016	0.088
Aster ericoides	0.000	0.000	0.035	0.149
Aster laevis	0.002	0.008	0.091	0.375
Chenopodium album	0.000	0.000	0.008	0.044
Cirsium arvense	0.009	0.048	0.066	0.185
Cirsium vulgare	0.000	0.000	0.000	0.000
Collomia linearis	0.000	0.000	0.005	0.027
Crepis tectorum	0.005	0.019	0.039	0.122
Draba species	0.157	0.830	0.000	0.000
Epilobium species	0.000	0.000	0.051	0.281
Geranium bicknellii	0.003	0.011	0.000	0.000
Geum species	0.000	0.000	0.000	0.000
Geum macrophyllum	0.000	0.000	0.036	0.197
Geum triflorum	0.004	0.020	0.000	0.000
Hedysarum alpinum	0.000	0.000	0.024	0.066
Lactuca pulchella	0.005	0.027	0.000	0.000
Lathyrus species	0.000	0.000	0.009	0.040
Lepidium densiflorum	0.000	0.000	0.006	0.033
Plantago species	0.055	0.299	0.000	0.000
Plantago major	0.000	0.000	0.326	1.096

Polygonum aviculare	0.000	0.000	0.042	0.095
Polygonum convulvulus	0.002	0.008	0.017	0.062
Rosa species	0.001	0.005	0.005	0.026
Rubus idaeus	0.000	0.000	0.007	0.038
Solidago rigida	0.000	0.000	0.048	0.263
Sonchus species	0.020	0.111	0.005	0.026
Stachys palustris	0.013	0.069	0.000	0.000
Symphoricarpos albus	0.002	0.008	0.000	0.000
Symphoricarpos occidentalis	0.005	0.013	0.055	0.133
Taraxacum officinale	0.058	0.134	0.186	0.466
Thermopsis rhombifolia	0.001	0.006	0.005	0.027
Thlaspi arvense	0.006	0.021	0.009	0.033
Vicia americana	0.012	0.030	0.008	0.040
Viola species	0.003	0.018	0.000	0.000
Weed seedling	0.001	0.003	0.053	0.088

n = 30

Table B.15. Mean percent ground cover by plant species on the seeded work zone in 1997 and 1998 at the Hardisty site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron species	0.000	0.000	0.052	0.190
Agropyron dasystachyum	0.029	0.066	0.184	0.488
Agropyron riparium	0.000	0.001	0.000	0.000
Agropyron smithii	0.008	0.016	0.099	0.369
Agrostis scabra	0.000	0.000	0.184	0.554
Agropyron subsecundum	0.014	0.071	0.456	1.371
Agropyron trachycaulum	0.023	0.047	0.909	1.228
Bromus inermis	0.011	0.058	0.015	0.082
Calamagrostis montanensis	0.000	0.000	0.000	0.000
Carex species	0.008	0.030	0.013	0.073
Dactylis glomerata	0.000	0.000	0.093	0.511
Festuca species	0.018	0.031	0.000	0.000
Festuca hallii	0.000	0.000	0.017	0.065
Festuca ovina	0.000	0.000	0.913	1.192
Grass seedling	0.000	0.001	0.000	0.000
Helictrotrichon hookeri	0.055	0.293	0.000	0.000
Koeleria macrantha	0.001	0.002	0.066	0.193
Poa species	0.000	0.000	0.072	0.393
Poa palustris	0.002	0.006	0.105	0.350
Poa pratensis/compressa	0.000	0.000	0.027	0.146
Stipa viridula	0.001	0.006	0.206	0.506
Achillea millefolium	0.002	0.010	0.005	0.029
Aster species	0.038	0.173	0.000	0.000
Aster ciliolatus	0.011	0.058	0.000	0.000
Aster conspicuus	0.000	0.000	0.000	0.000
Aster laevis	0.009	0.048	0.000	0.000
Chenopodium species	0.000	0.000	0.022	0.119
Chenopodium album	0.000	0.000	0.022	0.079
Cirsium arvense	0.002	0.011	0.037	0.122
Crepis tectorum	0.183	0.622	0.088	0.310
Descurainia sophia	0.000	0.000	0.007	0.037
Geranium species	0.000	0.002	0.019	0.102
Geranium bicknellii	0.021	0.075	0.000	0.000
Hedysarum alpinum	0.000	0.000	0.017	0.054
Lathyrus species	0.001	0.005	0.002	0.009
Lepidium densiflorum	0.000	0.000	0.011	0.046
Medicago sativa	0.003	0.019	0.020	0.110
Plantago species	0.012	0.065	0.000	0.000
Plantago major	0.001	0.008	0.000	0.000
Polygonum aviculare	0.000	0.000	0.012	0.064
Polygonum convulvulus	0.000	0.002	0.019	0.090

Polygonum species	0.000	0.000	0.027	0.146
Potentilla norvegica	0.000	0.000	0.010	0.055
Rosa species	0.002	0.008	0.003	0.015
Rubus idaeus	0.000	0.000	0.006	0.033
Solidago canadensis	0.000	0.000	0.034	0.129
Sonchus species	0.030	0.163	0.000	0.000
Symphoricarpos occidentalis	0.002	0.009	0.022	0.054
Taraxacum officinale	0.008	0.043	0.075	0.180
Thlaspi arvense	0.006	0.020	0.001	0.005
Vicia americana	0.016	0.043	0.001	0.007
Viola species	0.002	0.009	0.000	0.000
Weed seedling	0.000	0.000	0.030	0.164

n = 29 1997, n = 30 1998

Table B.16. Mean percent ground cover by plant species on the sodded spoil zone in 1997 and 1998 at the Hardisty site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	0.000	0.000	0.027	0.105
Agropyron smithii	0.008	0.021	0.033	0.183
Agrostis scabra	0.000	0.000	0.007	0.037
Agropyron subsecundum	0.344	0.709	0.759	1.501
Agropyron trachycaulum	0.005	0.021	0.061	0.186
Bromus anomalus	0.003	0.016	0.000	0.000
Bromus inermis	0.046	0.141	0.507	1.060
Calamagrostis montanensis	0.000	0.000	0.008	0.046
Carex species	0.172	0.345	0.152	0.255
Festuca hallii	0.014	0.056	0.053	0.203
Festuca idahoensis	0.468	2.364	0.000	0.000
Helictrotrichon hookeri	0.001	0.005	0.000	0.000
Hordeum jubatum	0.000	0.000	0.000	0.000
Koeleria macrantha	0.000	0.000	0.003	0.015
Poa species	0.000	0.000	0.189	1.035
Poa palustris	0.000	0.000	0.008	0.044
Poa pratensis/compressa	0.852	1.425	1.749	2.597
Achillea millefolium	0.740	2.342	0.487	0.874
Agoseris glauca	0.016	0.082	0.000	0.000
Ambrosia species	0.000	0.000	0.009	0.032
Antennaria parvifolia	0.135	0.478	0.000	0.000
Artemisia biennis	0.000	0.000	0.050	0.274
Artemisia frigida	0.047	0.241	0.013	0.050
Artemisia ludoviciana	0.013	0.035	0.102	0.298
Aster conspicuus	0.063	0.266	0.000	0.000
Aster ericoides	0.006	0.030	0.042	0.162
Aster laevis	0.052	0.263	0.107	0.350
Astragalus species	0.000	0.000	0.001	0.007
Astragalus striatus	0.000	0.000	0.003	0.016
Campanula rotundifolia	0.000	0.000	0.010	0.055
Cerastium arvense	0.006	0.028	0.017	0.047
Chenopodium species	0.000	0.000	0.013	0.073
Chenopodium album	0.003	0.013	0.018	0.091
Cirsium vulgare	0.000	0.000	0.048	0.263
Collomia linearis	0.000	0.000	0.001	0.007
Comandra umbellata	0.027	0.068	0.060	0.219
Crepis tectorum	0.000	0.000	0.026	0.119
Descurainia sophia	0.000	0.000	0.005	0.029
Draba species	0.002	0.008	0.000	0.000
Fragaria virginiana	0.015	0.073	0.004	0.022
Galium boreale	0.039	0.182	0.064	0.307

Geranium bicknellii	0.019	0.088	0.000	0.000
Geum macrophyllum	0.000	0.000	0.056	0.309
Hedysarum alpinum	0.000	0.000	0.010	0.055
Helianthus species	0.000	0.000	0.020	0.110
Heuchera richardsonii	0.003	0.016	0.000	0.000
Lactuca pulchella	0.096	0.458	0.388	1.059
Lappula species	0.000	0.000	0.023	0.110
Lathyrus species	0.001	0.004	0.000	0.000
Lepidium densiflorum	0.000	0.000	0.018	0.052
Oxytropis species	0.000	0.000	0.017	0.091
Penstemon species	0.078	0.157	0.000	0.000
Plantago species	0.044	0.218	0.000	0.000
Polygonum aviculare	0.000	0.000	0.008	0.027
Polygonum convulvulus	0.000	0.000	0.118	0.199
Populus tremuloides	0.012	0.059	0.000	0.000
Potentilla norvegica	0.000	0.000	0.196	0.817
Psoralea argophylla	0.071	0.156	0.000	0.000
Rosa species	0.043	0.079	0.095	0.298
Solidago species	0.000	0.000	0.117	0.509
Solidago canadensis	0.012	0.059	0.013	0.073
Solidago missouriensis	0.000	0.000	0.233	0.680
Solidago rigida	0.090	0.459	0.015	0.082
Symphoricarpos occidentalis	0.016	0.040	0.008	0.044
Taraxacum officinale	0.060	0.192	0.318	0.947
Thermopsis rhombifolia	0.000	0.000	0.161	0.422
Thlaspi arvense	0.000	0.000	0.002	0.011
Tragopogon dubius	0.000	0.000	0.006	0.033
Vicia americana	0.017	0.039	0.015	0.046
Viola adunca	0.003	0.018	0.009	0.034
Weed seedling	0.000	0.000	0.017	0.035

n = 26 1997, n = 30 1998

Table B.17. Mean percent ground cover by plant species on the sodded trench zone in 1997 and 1998 at the Hardisty site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	0.000	0.000	0.017	0.091
Agropyron smithii	0.041	0.169	0.112	0.340
Agrostis scabra	0.014	0.069	0.025	0.134
Agropyron subsecundum	1.015	3.401	1.003	1.529
Agropyron trachycaulum	0.004	0.022	0.000	0.000
Bouteloua gracilis	0.000	0.000	0.101	0.520
Bromus anomalus	0.021	0.113	0.000	0.000
Bromus inermis	0.008	0.034	0.363	1.957
Calamagrostis montanensis	0.004	0.019	0.000	0.000
Carex species	0.307	0.697	0.261	0.740
Festuca hallii	0.022	0.042	0.000	0.000
Festuca idahoensis	0.006	0.033	0.000	0.000
Hordeum jubatum	0.000	0.000	0.186	1.003
Koeleria macrantha	0.002	0.011	0.051	0.273
Muhlenbergia cuspidata	0.000	0.000	0.024	0.130
Poa alpinum	0.001	0.007	0.000	0.000
Poa palustris	0.010	0.055	0.000	0.000
Poa pratensis/compressa	1.890	7.761	2.489	2.840
Stipa viridula	0.002	0.009	0.316	1.213
Achillea millefolium	0.470	0.821	0.559	1.194
Amaranthus retroflexus	0.500	2.739	0.000	0.000
Ambrosia species	0.000	0.000	0.164	0.546
Artemisia frigida	0.000	0.000	0.008	0.045
Artemisia ludoviciana	0.042	0.184	0.213	0.556
Aster ericoides	0.028	0.085	0.076	0.235
Aster laevis	0.060	0.173	0.125	0.362
Astragalus species	0.022	0.109	0.001	0.006
Campanula rotundifolia	0.008	0.046	0.003	0.015
Capsella bursa-pastoris	0.000	0.000	0.000	0.000
Cerastium arvense	0.044	0.192	0.000	0.000
Chenopodium album	0.025	0.095	0.020	0.064
Cirsium arvense	0.000	0.000	0.008	0.045
Cirsium vulgare	0.015	0.084	0.000	0.000
Comandra umbellata	0.033	0.093	0.012	0.038
Crepis tectorum	0.007	0.037	0.000	0.000
Descurainia sophia	0.000	0.000	0.034	0.096
Galium boreale	0.000	0.000	0.021	0.068
Hedysarum alpinum	0.000	0.000	0.002	0.011
Lactuca pulchella	0.023	0.084	0.044	0.141
Lappula species	0.000	0.000	0.068	0.289
Lathyrus species	0.002	0.010	0.000	0.000

Lepidium densiflorum	0.000	0.000	0.222	1.038
Linnaea borealis	0.000	0.000	0.006	0.033
Sphaeralcea coccinea	0.000	0.000	0.002	0.013
Penstemon species	0.069	0.365	0.000	0.000
Plantago species	0.061	0.336	0.000	0.000
Polygonum aviculare	0.000	0.000	0.029	0.135
Polygonum convulvulus	0.022	0.084	0.146	0.153
Polygonum species	0.005	0.027	0.000	0.000
Potentilla norvegica	0.000	0.000	0.065	0.245
Psoralea species	0.001	0.004	0.000	0.000
Psoralea argophylla	0.011	0.025	0.000	0.000
Rosa species	0.013	0.033	0.034	0.079
Rubus idaeus	0.001	0.004	0.000	0.000
Salix species	0.000	0.000	0.039	0.212
Sisyrinchium monyanum	0.001	0.004	0.000	0.000
Solidago species	0.000	0.000	0.031	0.167
Solidago canadensis	0.057	0.312	0.033	0.178
Solidago missouriensis	0.000	0.000	0.154	0.395
Solidago rigida	0.005	0.027	0.219	0.793
Sonchus species	0.028	0.153	0.000	0.000
Stellaria species	0.037	0.183	0.000	0.000
Symphoricarpos albus	0.001	0.004	0.000	0.000
Symphoricarpos occidentalis	0.028	0.093	0.005	0.028
Taraxacum officinale	0.015	0.080	0.047	0.126
Thermopsis rhombifolia	0.009	0.047	0.016	0.045
Tragopogon dubius	0.001	0.007	0.000	0.000
Urtica dioica	0.000	0.000	0.000	0.000
Vicia americana	0.095	0.364	0.016	0.037
Viola species	0.001	0.007	0.000	0.000
Viola adunca	0.003	0.010	0.000	0.000
Weed seedling	0.000	0.000	0.004	0.016

n = 30 1997, n = 29 1998

Table B.18. Mean percent ground cover by plant species on the sodded work zone in 1997 and 1998 at the Hardisty site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	0.040	0.160	0.007	0.040
Agropyron smithii	0.085	0.230	0.091	0.280
Agropyron subsecundum	0.414	1.097	0.551	1.057
Agropyron trachycaulum	0.000	0.000	0.111	0.244
Bouteloua gracilis	0.000	0.000	0.064	0.329
Bromus ciliatus	0.000	0.000	0.023	0.128
Bromus inermis	0.000	0.000	0.133	0.366
Calamagrostis montanensis	0.017	0.069	0.000	0.000
Carex species	1.449	5.023	0.963	1.827
Festuca species	0.002	0.011	0.000	0.000
Festuca hallii	0.512	2.541	0.240	0.669
Helictrotrichon hookeri	0.001	0.004	0.000	0.000
Koeleria macrantha	0.001	0.005	0.022	0.086
Poa pratensis/compressa	0.978	1.763	3.998	4.678
Stipa curtiseta	0.000	0.000	0.113	0.412
Achillea millefolium	0.144	0.369	0.366	0.602
Agoseris glauca	0.013	0.073	0.000	0.000
Ambrosia species	0.000	0.000	0.013	0.073
Anenome species	0.000	0.000	0.005	0.026
Antennaria parvifolia	0.009	0.051	0.000	0.000
Artemisia frigida	0.006	0.024	0.207	0.992
Artemisia ludoviciana	0.013	0.035	0.050	0.183
Aster species	0.009	0.050	0.000	0.000
Aster ericoides	0.001	0.005	0.044	0.162
Aster laevis	0.111	0.503	0.020	0.078
Astragalus species	0.027	0.077	0.047	0.093
Campanula rotundifolia	0.000	0.000	0.004	0.020
Cerastium arvense	0.000	0.000	0.005	0.029
Chenopodium album	0.008	0.039	0.028	0.108
Cirsium arvense	0.043	0.237	0.000	0.000
Comandra umbellata	0.012	0.040	0.014	0.057
Crepis tectorum	0.033	0.179	0.000	0.000
Delphinium glauca	0.001	0.005	0.000	0.000
Descurainia sophia	0.000	0.000	0.021	0.069
Galium boreale	0.008	0.025	0.017	0.064
Geum species	0.005	0.029	0.000	0.000
Glechoma hederacea	0.003	0.010	0.000	0.000
Lactuca pulchella	0.044	0.132	0.125	0.336
Lathyrus species	0.000	0.000	0.017	0.095
Lepidium densiflorum	0.000	0.000	0.041	0.186
Sphaeralcea coccinea	0.000	0.000	0.008	0.044

Penstemon species	0.007	0.032	0.000	0.000
Polygonum aviculare	0.000	0.000	0.015	0.059
Polygonum convulvulus	0.000	0.000	0.063	0.124
Potentilla norvegica	0.000	0.000	0.030	0.164
Potemtilla gracilis	0.000	0.000	0.005	0.029
Potentilla anserina	0.005	0.026	0.000	0.000
Psoralea argophylla	0.003	0.018	0.000	0.000
Rosa species	0.013	0.042	0.103	0.483
Rubus idaeus	0.009	0.036	0.005	0.027
Solidago missouriensis	0.188	0.613	0.600	1.437
Symphoricarpos albus	0.001	0.004	0.000	0.000
Symphoricarpos occidentalis	0.053	0.105	0.157	0.368
Taraxacum officinale	0.056	0.181	0.233	0.923
Thermopsis rhombifolia	0.006	0.031	0.051	0.194
Tragopogon dubius	0.000	0.000	0.009	0.051
Vicia americana	0.077	0.176	0.061	0.128
Viola adunca	0.011	0.031	0.081	0.444
Weed seedling	0.000	0.000	0.004	0.024

n = 30

Table B.19. Mean plant species density per 0.1 meter square on undisturbed prairie in 1997 and 1998 at the Manyberries site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	1.167	1.599	2.000	5.146
Agropyron smithii	0.400	1.037	1.367	3.755
Agropyron subsecundum	0.100	0.305	0.000	0.000
Agropyron trachycaulum	0.000	0.000	0.067	0.365
Bouteloua gracilis	0.167	0.747	0.067	0.254
Calamagrostis montanensis	0.000	0.000	0.067	0.365
Carex species	14.100	15.533	10.700	10.124
Danthonia species	0.200	0.805	0.233	0.626
Festuca hallii	10.367	10.473	4.933	4.856
Festuca idahoensis	0.000	0.000	0.667	1.295
Helictrotrichon hookeri	0.000	0.000	0.167	0.531
Koeleria macrantha	0.433	1.524	0.367	1.066
Poa species	0.133	0.571	0.000	0.000
Poa pratensis/compressa	3.233	14.388	2.500	6.490
Stipa curtiseta	2.267	3.172	1.200	2.845
Stipa viridula	1.267	3.300	0.367	0.890
Achillea millefolium	1.067	3.279	0.933	3.140
Agoseris glauca	0.033	0.183	0.000	0.000
Anenome species	0.000	0.000	0.133	0.346
Anenome patens	0.067	0.254	0.000	0.000
Antennaria parvifolia	1.067	3.667	0.367	1.129
Artemisia frigida	0.100	0.403	0.333	0.959
Artemisia ludoviciana	2.833	3.806	0.900	2.123
Aster species	0.033	0.183	0.000	0.000
Aster ericoides	2.367	3.168	0.500	1.697
Aster laevis	0.000	0.000	0.033	0.183
Astragalus species	0.000	0.000	0.133	0.730
Astragalus striatus	0.000	0.000	0.033	0.183
Campanula rotundifolia	0.000	0.000	0.000	0.000
Cerastium arvense	0.067	0.254	0.000	0.000
Comandra umbellata	0.000	0.000	0.067	0.365
Elaeagnus species	0.100	0.548	0.000	0.000
Geum triflorum	0.033	0.183	0.033	0.183
Grindelia squarosa	0.033	0.183	0.000	0.000
Heterotheca villosa	0.033	0.183	1.467	3.350
Phlox hoodii	0.000	0.000	0.033	0.183
Rosa species	0.033	0.183	0.200	0.761
Solidago species	0.533	1.717	0.000	0.000
Solidago missouriensis	0.000	0.000	1.133	3.235
Symphoricarpos albus	0.500	1.167	0.000	0.000
Symphoricarpos	0.000	0.000	0.533	1.634

occidentalis				
Taraxacum officinale	0.000	0.000	0.167	0.747
Thermopsis rhombifolia	0.133	0.434	0.033	0.183
Vicia americana	0.000	0.000	0.333	0.661

n = 30

Table B.20. Mean plant species density per 0.1 meter square on the seeded spoil zone in 1997 and 1998 at the Manyberries site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	1.850	1.688	1.075	1.403
Agropyron riparium	0.025	0.158	0.000	0.000
Agropyron smithii	0.325	0.764	1.500	1.908
Agrostis scabra	0.000	0.000	0.075	0.350
Agropyron subsecundum	0.025	0.158	0.050	0.221
Agropyron trachycaulum	1.575	2.024	1.450	1.739
Bouteloua gracilis	0.025	0.158	0.300	1.454
Bromus inermis	0.000	0.000	0.025	0.158
Calamagrostis montanensis	0.000	0.000	0.025	0.158
Carex species	3.000	6.656	2.350	4.117
Festuca hallii	0.700	1.924	0.400	0.871
Festuca idahoensis	0.000	0.000	0.000	0.000
Grass seedling	0.650	1.388	0.025	0.158
Helictrotrichon hookeri	0.075	0.474	0.025	0.158
Hordeum jubatum	0.025	0.158	0.025	0.158
Koeleria macrantha	2.875	7.328	1.800	1.964
Muhlenbergia richardsonis	0.100	0.379	0.025	0.158
Poa pratensis/compressa	0.825	2.037	0.550	2.342
Stipa curtiseta	0.075	0.267	0.075	0.350
Stipa viridula	0.050	0.221	0.450	0.815
Achillea millefolium	0.575	2.275	0.375	1.170
Anenome species	0.025	0.158	0.000	0.000
Anenome patens	0.000	0.000	0.050	0.221
Artemisia frigida	0.050	0.221	0.150	0.362
Artemisia ludoviciana	0.475	1.679	0.625	1.750
Aster ericoides	1.050	2.353	0.250	0.899
Astragalus species	0.075	0.474	0.200	0.723
Astragalus pectinatus	0.200	0.608	0.025	0.158
Astragalus striatus	0.000	0.000	0.375	1.427
Chenopodium species	0.000	0.000	0.075	0.267
Cirsium species	0.025	0.158	0.000	0.000
Cirsium arvense	0.050	0.316	0.000	0.000
Descurainia sophia	0.075	0.267	0.025	0.158
Elaeagnus species	0.000	0.000	0.000	0.000
Erigeron species	0.000	0.000	0.000	0.000
Gaillardia aristida	0.000	0.000	0.075	0.350
Geum triflorum	0.025	0.158	0.000	0.000
Grindelia squarosa	0.025	0.158	0.000	0.000
Gutierrezia sarothrae	0.000	0.000	0.025	0.158
Heterotheca villosa	0.025	0.158	0.300	1.305
Lathyrus species	0.000	0.000	0.025	0.158

Lygodesmia juncea	0.000	0.000	0.075	0.474
Monolepis nuttalliana	0.025	0.158	0.000	0.000
Oxytropis sericea	0.250	0.707	0.000	0.000
Phlox hoodii	0.025	0.158	0.000	0.000
Ranunculus species	0.050	0.316	0.000	0.000
Ratibida columnifera	0.025	0.158	0.000	0.000
Rosa species	0.100	0.632	0.025	0.158
Salaola kali	0.025	0.158	0.000	0.000
Solidago species	0.325	1.403	0.000	0.000
Solidago missouriensis	0.075	0.474	0.450	1.154
Symphoricarpos occidentalis	0.000	0.000	0.075	0.267
Taraxacum officinale	0.000	0.000	0.000	0.000
Thermopsis rhombifolia	0.225	0.733	0.275	0.679
Thlaspi arvense	0.100	0.496	0.025	0.158
Vicia americana	0.000	0.000	0.200	0.464
Triticum aestivum	1.175	1.907	0.225	0.620

n = 40

Table B.21. Mean plant species density per 0.1 meter square on the seeded trench zone in 1997 and 1998 at the Manyberries site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	1.100	1.215	1.550	1.753
Agropyron smithii	0.125	0.463	1.075	1.309
Agropyron subsecundum	0.025	0.158	0.000	0.000
Agropyron trachycaulum	5.250	3.550	4.900	2.725
Carex species	0.100	0.496	0.175	0.675
Danthonia species	0.025	0.158	0.000	0.000
Festuca seedling	0.000	0.000	0.025	0.158
Festuca species	0.000	0.000	0.175	0.594
Festuca hallii	0.350	1.272	0.275	0.751
Grass seedling	0.575	1.196	0.000	0.000
Helictrotrichon hookeri	0.000	0.000	0.025	0.158
Hordeum jubatum	0.025	0.158	0.125	0.335
Koeleria macrantha	0.125	0.516	1.025	1.405
Stipa comata	0.000	0.000	0.025	0.158
Stipa viridula	0.025	0.158	0.150	0.427
Artemisia frigida	0.000	0.000	0.075	0.267
Descurainia sophia	0.025	0.158	0.000	0.000
Kochia scoparia	0.050	0.221	0.000	0.000
Rosa species	0.000	0.000	0.025	0.158
Salaola kali	0.075	0.267	0.000	0.000
Solidago rigida	0.025	0.158	0.000	0.000
Symphoricarpos occidentalis	0.000	0.000	0.025	0.158
Taraxacum officinale	0.000	0.000	0.025	0.158
Triticum aestivum	3.300	3.299	0.375	0.952

n = 40

Table B.22. Mean plant species density per 0.1 meter square on the seeded work zone in 1997 and 1998 at the Manyberries site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	0.600	1.033	0.700	1.091
Agropyron riparium	0.000	0.000	0.025	0.158
Agropyron smithii	0.100	0.496	0.850	1.748
Agrostis scabra	0.000	0.000	0.075	0.267
Agropyron trachycaulum	1.300	2.452	1.725	3.258
Calamagrostis montanensis	0.000	0.000	0.075	0.474
Carex species	1.750	4.824	1.775	4.179
Danthonia species	0.000	0.000	0.025	0.158
Danthonia spicatum	0.025	0.158	0.000	0.000
Festuca species	0.000	0.000	0.150	0.949
Festuca hallii	1.375	4.342	1.175	2.836
Festuca idahoensis	0.000	0.000	0.150	0.949
Grass seedling	0.675	2.526	0.000	0.000
Helictrotrichon hookeri	0.075	0.474	0.075	0.267
Hordeum jubatum	0.025	0.158	0.025	0.158
Koeleria macrantha	0.500	1.086	1.275	1.694
Muhlenbergia richardsonis	0.125	0.516	0.000	0.000
Poa species	0.000	0.000	0.025	0.158
Poa pratensis/compressa	0.150	0.483	0.425	1.500
Stipa comata	0.000	0.000	0.050	0.316
Stipa curtiseta	0.000	0.000	0.150	0.662
Stipa viridula	0.150	0.427	0.400	1.317
Achillea millefolium	0.200	0.853	0.050	0.316
Amaranthus albus	0.025	0.158	0.000	0.000
Amaranthus retroflexus	0.000	0.000	0.250	0.927
Androsace septentrionalis	0.025	0.158	0.000	0.000
Anenome species	0.050	0.221	0.025	0.158
Anenome patens	0.000	0.000	0.075	0.267
Antennaria parvifolia	0.000	0.000	0.075	0.267
Arenarias species	0.000	0.000	0.050	0.316
Artemisia cana	0.025	0.158	0.000	0.000
Artemisia frigida	0.050	0.221	0.100	0.304
Artemisia ludoviciana	0.250	1.006	0.700	1.652
Aster conspicuus	0.025	0.158	0.000	0.000
Aster ericoides	0.500	2.000	0.175	0.675
Astragalus species	0.100	0.496	0.000	0.000
Astragalus pectinatus	0.075	0.474	0.000	0.000
Astragalus striatus	0.000	0.000	0.125	0.791
Campanula rotundifolia	0.025	0.158	0.000	0.000
Chenopodium species	0.000	0.000	0.025	0.158
Comandra umbellata	0.025	0.158	0.000	0.000

Gaillardia aristida	0.000	0.000	0.025	0.158
Gutierrezia sarothrae	0.000	0.000	0.025	0.158
Haplopappus spinulosus	0.000	0.000	0.000	0.000
Heterotheca villosa	0.125	0.791	0.075	0.350
Lathyrus species	0.000	0.000	0.200	0.823
Monolepis nuttalliana	0.025	0.158	0.000	0.000
Oxytropis species	0.000	0.000	0.025	0.158
Potentilla species	0.000	0.000	0.025	0.158
Potentilla anserina	0.000	0.000	0.025	0.158
Rosa species	0.050	0.221	0.225	0.974
Sisyrinchium montanum	0.000	0.000	0.025	0.158
Solanum triflorum	0.025	0.158	0.000	0.000
Solidago species	0.100	0.441	0.000	0.000
Solidago missouriensis	0.000	0.000	0.600	1.317
Symphoricarpos albus	0.025	0.158	0.000	0.000
Symphoricarpos occidentalis	0.000	0.000	0.075	0.474
Taraxacum officinale	0.000	0.000	0.075	0.267
Thermopsis rhombifolia	0.225	0.768	0.200	0.648
Vicia americana	0.000	0.000	0.125	0.404
Weed seedling	0.050	0.316	0.125	0.563
Triticum aestivum	0.900	2.098	0.000	0.000

n = 40

Table B.23. Mean plant species density per 0.1 meter square on the sodded spoil zone in 1997 and 1998 at the Manyberries site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	1.550	4.181	1.875	3.376
Agropyron repens	0.075	0.474	0.000	0.000
Agropyron smithii	0.250	0.630	0.425	0.874
Agropyron trachycaulum	0.300	0.758	0.500	0.934
Bouteloua gracilis	0.050	0.221	0.000	0.000
Calamagrostis montanensis	0.100	0.441	0.000	0.000
Carex species	10.300	15.978	5.175	8.271
Danthonia species	[illegible].025	0.158	0.025	0.158
Festuca hallii	4.525	6.152	2.125	3.236
Festuca idahoensis	0.275	0.905	0.750	1.597
Grass seedling	0.025	0.158	0.000	0.000
Helictrotrichon hookeri	0.175	0.501	0.275	0.679
Hordeum jubatum	0.025	0.158	0.025	0.158
Koeleria macrantha	2.000	3.486	1.350	1.902
Oryzopsis hymenoides	0.000	0.000	0.025	0.158
Stipa curtiseta	0.350	0.864	0.875	1.977
Stipa viridula	0.000	0.000	0.050	0.221
Achillea millefolium	0.275	1.037	0.050	0.316
Anenome species	0.025	0.158	0.175	0.501
Anenome patens	0.000	0.000	0.200	0.687
Artemisia cana	0.000	0.000	0.025	0.158
Artemisia frigida	0.125	0.516	0.000	0.000
Artemisia ludoviciana	0.875	2.232	1.200	2.431
Aster species	0.125	0.791	0.000	0.000
Aster ericoides	0.675	2.325	0.375	1.295
Astragalus species	0.150	0.662	0.000	0.000
Astragalus pectinatus	0.450	1.085	0.025	0.158
Astragalus striatus	0.000	0.000	0.350	1.122
Campanula rotundifolia	0.050	0.221	0.000	0.000
Chenopodium species	0.000	0.000	0.050	0.221
Cirsium arvense	0.050	0.221	0.000	0.000
Comandra umbellata	0.000	0.000	0.025	0.158
Erigeron species	0.000	0.000	0.025	0.158
Gaillardia aristida	0.000	0.000	0.025	0.158
Galium boreale	0.225	1.143	0.000	0.000
Geum species	0.025	0.158	0.000	0.000
Haplopappus spinulosus	0.025	0.158	0.000	0.000
Heterotheca villosa	0.050	0.221	0.000	0.000
Sphaeralcea coccinea	0.050	0.316	0.000	0.000
Medicago sativa	0.025	0.158	0.000	0.000
Melilotus officinalis	0.000	0.000	0.025	0.158

Oxytropis sericea	0.100	0.632	0.000	0.000
Phlox hoodii	0.050	0.316	0.225	0.620
Plantago major	0.025	0.158	0.000	0.000
Rosa species	0.050	0.316	0.000	0.000
Solidago species	0.125	0.516	0.000	0.000
Solidago missouriensis	0.000	0.000	0.900	3.921
Symphoricarpos albus	0.075	0.267	0.000	0.000
Symphoricarpos occidentalis	0.000	0.000	0.175	0.675
Taraxacum officinale	0.000	0.000	0.025	0.158
Thermopsis rhombifolia	0.025	0.158	0.000	0.000
Tragopogon dubius	0.025	0.158	0.000	0.000
Trifolium pratense	0.025	0.158	0.000	0.000
Vicia americana	0.000	0.000	0.650	1.312

n = 40

Table B.24. Mean plant species density per 0.1 meter square on the sodded trench zone in 1997 and 1998 at the Manyberries site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron species	0.000	0.000	0.050	0.221
Agropyron dasystachyum	0.400	0.955	0.050	0.221
Agropyron trachycaulum	0.275	0.816	0.175	0.958
Bouteloua gracilis	0.025	0.158	0.000	0.000
Bromus inermis	0.000	0.000	0.025	0.158
Calamagrostis montanensis	0.050	0.316	0.000	0.000
Carex species	4.775	4.452	7.100	9.134
Distichlis stricta	0.050	0.316	0.000	0.000
Festuca hallii	4.700	4.485	3.200	4.363
Festuca idahoensis	0.150	0.580	0.375	0.868
Helictrotrichon hookeri	0.175	0.549	0.400	0.871
Hordeum jubatum	0.050	0.221	0.025	0.158
Koeleria macrantha	2.475	2.063	2.825	1.920
Muhlenbergia species	0.125	0.791	0.000	0.000
Muhlenbergia richardsonis	0.050	0.316	0.150	0.580
Poa pratensis/compressa	0.500	3.004	0.075	0.350
Stipa comata	0.025	0.158	0.000	0.000
Stipa curtiseta	0.300	0.911	0.400	1.277
Stipa viridula	0.025	0.158	0.000	0.000
Agoseris glauca	0.025	0.158	0.000	0.000
Allium cernuum	0.025	0.158	0.000	0.000
Amaranthus albus	0.025	0.158	0.050	0.316
Amaranthus retroflexus	0.000	0.000	0.025	0.158
Androsace septentrionalis	0.050	0.221	0.100	0.379
Anenome species	0.000	0.000	0.075	0.267
Arenarias species	0.000	0.000	0.025	0.158
Artemisia frigida	0.125	0.335	0.050	0.221
Artemisia ludoviciana	0.050	0.221	0.100	0.632
Aster conspicuus	0.025	0.158	0.000	0.000
Astragalus species	0.025	0.158	0.000	0.000
Astragalus pectinatus	0.025	0.158	0.050	0.316
Chenopodium species	0.000	0.000	0.125	0.335
Cirsium vulgare	0.025	0.158	0.150	0.662
Geum triflorum	0.025	0.158	0.000	0.000
Grindelia squarosa	0.050	0.221	0.025	0.158
Gutierrezia sarothrae	0.000	0.000	0.075	0.267
Liatrus punctata	0.050	0.316	0.000	0.000
Linum lewisii	0.075	0.474	0.000	0.000
Melilotus officinalis	0.000	0.000	0.025	0.158
Oxytropis species	0.050	0.316	0.000	0.000
Oxytropis sericea	0.075	0.474	0.000	0.000

Potentilla species	0.000	0.000	0.025	0.158
Solanum triflorum	0.000	0.000	0.050	0.221
Taraxacum officinale	0.025	0.158	0.025	0.158
Tragopogon dubius	0.075	0.350	0.000	0.000
Trifolium hybridum	0.125	0.404	0.000	0.000
Vicia americana	0.000	0.000	0.200	0.648
Triticum aestivum	0.075	0.267	0.000	0.000

n = 40

Table B.25. Mean plant species density per 0.1 meter square on the sodded work zone in 1997 and 1998 at the Manyberries site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron species	0.000	0.000	0.200	1.114
Agropyron dasystachyum	1.375	1.931	0.225	0.577
Agropyron smithii	0.425	1.466	1.075	2.576
Agropyron trachycaulum	1.075	1.655	0.750	1.276
Agrostis scabra	0.000	0.000	0.050	0.221
Bouteloua gracilis	0.000	0.000	0.025	0.158
Bromus inermis	0.050	0.316	0.000	0.000
Calamagrostis montanensis	0.000	0.000	0.075	0.474
Carex species	5.750	11.003	2.450	3.762
Danthonia species	0.050	0.221	0.025	0.158
Danthonia spicatum	0.050	0.316	0.000	0.000
Festuca seedling	0.000	0.000	0.025	0.158
Festuca hallii	2.275	4.045	1.200	2.090
Festuca idahoensis	0.025	0.158	0.000	0.000
Grass seedling	0.425	1.083	0.000	0.000
Helictrotrichon hookeri	0.025	0.158	0.000	0.000
Hordeum jubatum	0.000	0.000	0.075	0.267
Koeleria macrantha	1.125	1.381	1.350	1.703
Oryzopsis hymenoides	0.025	0.158	0.000	0.000
Poa pratensis/compressa	0.025	0.158	0.000	0.000
Stipa comata	0.150	0.802	0.025	0.158
Stipa curtiseta	0.050	0.221	0.600	1.172
Stipa viridula	0.125	0.563	0.025	0.158
Achillea millefolium	0.150	0.802	0.000	0.000
Androsace septentrionalis	0.000	0.000	0.075	0.267
Anenome species	0.000	0.000	0.150	0.427
Anenome patens	0.000	0.000	0.050	0.221
Artemisia cana	0.025	0.158	0.000	0.000
Artemisia frigida	0.050	0.221	0.075	0.350
Artemisia ludoviciana	0.200	0.791	0.475	1.301
Aster ericoides	0.000	0.000	0.325	1.269
Astragalus species	0.025	0.158	0.025	0.158
Astragalus pectinatus	0.725	1.198	0.000	0.000
Astragalus striatus	0.000	0.000	0.100	0.632
Chenopodium species	0.150	0.427	0.300	0.911
Descurainia sophia	0.050	0.221	0.000	0.000
Erigeron species	0.000	0.000	0.125	0.404
Gaillardia aristida	0.025	0.158	0.000	0.000
Geum triflorum	0.050	0.221	0.000	0.000
Grindelia squarosa	0.000	0.000	0.075	0.350
Gutierrezia sarothrae	0.000	0.000	0.000	0.000

Haplopappus spinulosus	0.075	0.474	0.000	0.000
Heterotheca villosa	0.025	0.158	0.000	0.000
Lathyrus species	0.000	0.000	0.600	1.411
Liatrus punctata	0.025	0.158	0.000	0.000
Monolepis nuttalliana	0.025	0.158	0.000	0.000
Oxytropis sericea	0.025	0.158	0.000	0.000
Phlox hoodii	0.025	0.158	0.000	0.000
Psoralea species	0.025	0.158	0.000	0.000
Salaola kali	0.025	0.158	0.000	0.000
Solanum triflorum	0.125	0.791	0.075	0.350
Solidago missouriensis	0.000	0.000	0.200	1.114
Stellaria species	0.000	0.000	0.025	0.158
Symphoricarpos occidentalis	0.000	0.000	0.025	0.158
Thermopsis rhombifolia	0.025	0.158	0.000	0.000
Trifolium hybridum	0.025	0.158	0.000	0.000
Trifolium pratense	0.050	0.221	0.000	0.000
Vicia americana	0.000	0.000	0.425	0.931
Weed seedling	0.025	0.158	0.000	0.000
Triticum aestivum	0.050	0.221	0.000	0.000

n = 40

Table B.26. Mean percent ground cover by plant species on undisturbed prairie in 1997 and 1998 at the Manyberries site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	0.107	0.164	0.288	0.660
Agropyron smithii	0.031	0.081	0.225	0.607
Agropyron subsecundum	0.007	0.027	0.000	0.000
Agropyron trachycaulum	0.000	0.000	0.004	0.022
Bouteloua gracilis	0.006	0.028	0.040	0.161
Calamagrostis montanensis	0.000	0.000	0.012	0.064
Carex species	0.489	0.660	1.277	1.851
Danthonia species	0.004	0.017	0.049	0.135
Festuca hallii	4.604	3.781	1.819	2.422
Festuca idahoensis	0.000	0.000	0.098	0.244
Helictrotrichon hookeri	0.000	0.000	0.064	0.211
Koeleria macrantha	0.030	0.088	0.139	0.408
Poa species	0.007	0.033	0.000	0.000
Poa pratensis/compressa	0.299	0.930	0.318	0.917
Stipa curtiseta	0.753	1.327	0.352	0.842
Stipa viridula	0.407	1.103	0.193	0.624
Achillea millefolium	0.035	0.081	0.045	0.125
Agoseris glauca	0.002	0.011	0.000	0.000
Anenome patens	0.010	0.044	0.000	0.000
Antennaria parvifolia	0.050	0.175	0.058	0.143
Artemisia frigida	0.030	0.153	0.041	0.150
Artemisia ludoviciana	0.540	1.186	0.072	0.166
Aster species	0.005	0.027	0.000	0.000
Aster ericoides	0.069	0.095	0.037	0.124
Aster laevis	0.000	0.000	0.003	0.015
Astragalus species	0.000	0.000	0.002	0.011
Astragalus striatus	0.000	0.000	0.003	0.016
Cerastium arvense	0.005	0.018	0.000	0.000
Comandra umbellata	0.000	0.000	0.010	0.055
Elaeagnus species	0.050	0.274	0.000	0.000
Geum triflorum	0.005	0.026	0.008	0.044
Grindelia squarosa	0.022	0.120	0.000	0.000
Heterotheca villosa	0.002	0.009	0.075	0.177
Phlox hoodii	0.000	0.000	0.012	0.066
Rosa species	0.002	0.011	0.017	0.053
Solidago species	0.012	0.038	0.000	0.000
Solidago missouriensis	0.000	0.000	0.115	0.269
Symphoricarpos albus	0.211	0.629	0.000	0.000
Symphoricarpos occidentalis	0.000	0.000	0.080	0.240
Taraxacum officinale	0.000	0.000	0.019	0.078

Thermopsis rhombifolia	0.019	0.064	0.004	0.022
Vicia americana	0.000	0.000	0.015	0.030

n = 30

Table B.27. Mean percent ground cover by plant species on the seeded spoil zone in 1997 and 1998 at the Manyberries site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	0.129	0.292	0.573	1.166
Agropyron riparium	0.002	0.013	0.000	0.000
Agropyron smithii	0.022	0.059	0.568	0.940
Agrostis scabra	0.000	0.000	0.013	0.058
Agropyron subsecundum	0.005	0.033	0.096	0.437
Agropyron trachycaulum	0.114	0.162	1.120	1.535
Bouteloua gracilis	0.003	0.016	0.052	0.213
Bromus inermis	0.000	0.000	0.022	0.135
Calamagrostis montanensis	0.000	0.000	0.008	0.048
Carex species	0.287	0.765	0.494	0.861
Festuca hallii	0.051	0.148	0.105	0.324
Grass seedling	0.002	0.005	0.000	0.002
Helictrotrichon hookeri	0.003	0.019	0.008	0.051
Hordeum jubatum	0.000	0.003	0.054	0.336
Koeleria macrantha	0.070	0.150	0.761	1.556
Muhlenbergia richardsonis	0.007	0.026	0.004	0.022
Poa pratensis/compressa	0.650	3.234	0.308	1.589
Stipa curtiseta	0.003	0.013	0.085	0.417
Stipa viridula	0.003	0.016	0.257	0.530
Achillea millefolium	0.208	0.940	0.045	0.157
Anenome species	0.001	0.004	0.000	0.000
Anenome patens	0.000	0.000	0.009	0.049
Artemisia frigida	0.008	0.035	0.128	0.720
Artemisia ludoviciana	0.368	1.663	0.064	0.200
Aster ericoides	0.389	0.961	0.126	0.530
Astragalus species	0.103	0.644	0.022	0.086
Astragalus pectinatus	0.005	0.018	0.003	0.016
Astragalus striatus	0.000	0.000	0.009	0.027
Chenopodium species	0.000	0.000	0.001	0.004
Cirsium species	0.240	1.497	0.000	0.000
Descurainia sophia	0.012	0.047	0.001	0.008
Gaillardia aristida	0.000	0.000	0.010	0.047
Geum triflorum	0.020	0.123	0.000	0.000
Grindelia squarosa	0.010	0.064	0.000	0.000
Gutierrezia sarothrae	0.000	0.000	0.002	0.010
Heterotheca villosa	0.005	0.032	0.025	0.114
Lathyrus species	0.000	0.000	0.008	0.048
Lygodesmia juncea	0.000	0.000	0.001	0.005
Monolepis nuttalliana	0.025	0.159	0.000	0.000
Oxytropis sericea	0.010	0.031	0.000	0.000
Phlox hoodii	0.000	0.001	0.000	0.000

Ranunculus species	0.010	0.064	0.000	0.000
Ratibida columnifera	0.008	0.053	0.000	0.000
Rosa species	0.014	0.086	0.002	0.014
Salaola kali	0.000	0.002	0.000	0.000
Solidago species	0.078	0.443	0.000	0.000
Solidago missouriensis	0.057	0.358	0.259	1.187
Symphoricarpos occidentalis	0.000	0.000	0.013	0.054
Thermopsis rhombifolia	0.005	0.017	0.040	0.126
Thlaspi arvense	0.083	0.468	0.001	0.005
Vicia americana	0.000	0.000	0.013	0.037
Triticum aestivum	0.110	0.354	0.078	0.223

n = 39

Table B.28. Mean percent ground cover by plant species on the seeded trench zone in 1997 and 1998 at the Manyberries site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	0.019	0.023	0.852	1.295
Agropyron smithii	0.002	0.006	0.403	0.576
Agropyron subsecundum	0.000	0.001	0.000	0.000
Agropyron trachycaulum	0.137	0.139	3.400	2.272
Carex species	0.001	0.006	0.054	0.299
Danthonia species	0.000	0.001	0.000	0.000
Festuca seedling	0.000	0.000	0.003	0.016
Festuca species	0.000	0.000	0.013	0.042
Festuca hallii	0.001	0.005	0.055	0.141
Grass seedling	0.005	0.017	0.000	0.000
Helictrotrichon hookeri	0.000	0.000	0.001	0.008
Hordeum jubatum	0.000	0.002	0.078	0.224
Koeleria macrantha	0.003	0.016	0.268	0.421
Stipa comata	0.000	0.000	0.001	0.008
Stipa viridula	0.000	0.002	0.069	0.219
Artemisia frigida	0.000	0.000	0.023	0.100
Kochia scoparia	0.001	0.005	0.000	0.000
Rosa species	0.000	0.000	0.002	0.013
Salaola kali	0.002	0.009	0.000	0.000
Solidago rigida	0.003	0.019	0.000	0.000
Triticum aestivum	0.071	0.072	0.265	0.689

n = 39 1997, n = 40 1998

Table B.29. Mean percent ground cover by plant species on the seeded work zone in 1997 and 1998 at the Manyberries site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	0.036	0.090	0.545	1.442
Agropyron riparium	0.000	0.000	0.005	0.028
Agropyron smithii	0.024	0.118	0.211	0.458
Agrostis scabra	0.000	0.000	0.087	0.394
Agropyron trachycaulum	0.072	0.134	1.155	2.262
Calamagrostis montanensis	0.000	0.000	0.006	0.038
Carex species	0.105	0.313	0.267	0.601
Danthonia species	0.000	0.000	0.013	0.079
Danthonia spicatum	0.005	0.034	0.000	0.000
Festuca species	0.000	0.000	0.004	0.025
Festuca hallii	0.107	0.411	0.379	0.944
Festuca idahoensis	0.000	0.000	0.005	0.033
Grass seedling	0.008	0.033	0.000	0.000
Helictrotrichon hookeri	0.012	0.073	0.058	0.244
Hordeum jubatum	0.004	0.025	0.013	0.079
Koeleria macrantha	0.049	0.134	0.597	0.838
Muhlenbergia richardsonis	0.014	0.063	0.000	0.000
Poa species	0.000	0.000	0.007	0.043
Poa pratensis/compressa	0.030	0.150	0.135	0.428
Stipa comata	0.000	0.000	0.002	0.009
Stipa curtiseta	0.000	0.000	0.041	0.223
Stipa viridula	0.032	0.104	0.442	1.363
Achillea millefolium	0.086	0.335	0.002	0.013
Amaranthus albus	0.000	0.002	0.000	0.000
Amaranthus retroflexus	0.000	0.000	0.028	0.130
Androsace septentrionalis	0.001	0.006	0.000	0.000
Anenome species	0.007	0.034	0.002	0.009
Anenome patens	0.000	0.000	0.019	0.078
Antennaria parvifolia	0.000	0.000	0.016	0.059
Arenarias species	0.000	0.000	0.001	0.006
Artemisia cana	0.028	0.177	0.000	0.000
Artemisia frigida	0.010	0.054	0.206	0.972
Artemisia ludoviciana	0.074	0.324	0.249	0.811
Aster conspicuus	0.001	0.006	0.000	0.000
Aster ericoides	0.187	0.725	0.071	0.255
Astragalus species	0.028	0.136	0.000	0.000
Astragalus pectinatus	0.000	0.003	0.000	0.000
Astragalus striatus	0.000	0.000	0.005	0.033
Campanula rotundifolia	0.002	0.011	0.000	0.000
Chenopodium species	0.000	0.000	0.002	0.014
Comandra umbellata	0.001	0.007	0.000	0.000

Gaillardia aristida	0.000	0.000	0.002	0.013
Gutierrezia sarothrae	0.000	0.000	0.017	0.104
Heterotheca villosa	0.042	0.262	0.060	0.273
Lathyrus species	0.000	0.000	0.193	0.959
Monolepis nuttalliana	0.002	0.015	0.000	0.000
Oxytropis species	0.000	0.000	0.005	0.033
Potentilla species	0.000	0.000	0.002	0.009
Potentilla anserina	0.000	0.000	0.007	0.043
Rosa species	0.002	0.010	0.042	0.195
Sisyrinchium montanum	0.000	0.000	0.001	0.006
Solanum triflorum	0.007	0.041	0.000	0.000
Solidago species	0.014	0.079	0.000	0.000
Solidago missouriensis	0.000	0.000	0.193	0.452
Symphoricarpos occidentalis	0.000	0.000	0.002	0.013
Taraxacum officinale	0.000	0.000	0.058	0.258
Thermopsis rhombifolia	0.008	0.032	0.045	0.216
Vicia americana	0.000	0.000	0.303	1.399
Weed seedling	0.000	0.001	0.003	0.014
Triticum aestivum	0.030	0.065	0.000	0.000

n = 40

Table B.30. Mean percent ground cover by plant species on the sodded spoil zone in 1997 and 1998 at the Manyberries site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	0.159	0.525	0.502	0.879
Agropyron repens	0.001	0.008	0.000	0.000
Agropyron smithii	0.024	0.077	0.360	1.231
Agropyron trachycaulum	0.023	0.054	0.542	1.409
Bouteloua gracilis	0.019	0.101	0.000	0.000
Calamagrostis montanensis	0.005	0.021	0.000	0.000
Carex species	0.401	0.669	0.713	1.086
Danthonia species	0.003	0.021	0.005	0.032
Festuca hallii	0.708	1.357	0.556	1.026
Festuca idahoensis	0.097	0.369	0.330	0.811
Helictrotrichon hookeri	0.027	0.083	0.081	0.207
Hordeum jubatum	0.024	0.152	0.003	0.019
Koeleria macrantha	0.296	0.510	0.752	1.538
Stipa curtiseta	0.030	0.066	0.462	1.143
Stipa viridula	0.000	0.000	0.033	0.155
Achillea millefolium	0.198	1.095	0.002	0.009
Anenome species	0.002	0.011	0.005	0.017
Anenome patens	0.000	0.000	0.102	0.368
Artemisia cana	0.000	0.000	0.004	0.025
Artemisia frigida	0.018	0.074	0.000	0.000
Artemisia ludoviciana	0.402	1.385	0.400	1.215
Aster species	0.009	0.054	0.000	0.000
Aster ericoides	0.220	0.698	0.056	0.210
Astragalus species	0.111	0.663	0.000	0.000
Astragalus pectinatus	0.014	0.035	0.002	0.014
Astragalus striatus	0.000	0.000	0.025	0.106
Campanula rotundifolia	0.014	0.080	0.000	0.000
Chenopodium species	0.000	0.000	0.004	0.016
Cirsium arvense	0.001	0.005	0.000	0.000
Comandra umbellata	0.000	0.000	0.002	0.014
Erigeron species	0.000	0.000	0.070	0.443
Gaillardia aristida	0.000	0.000	0.061	0.387
Galium boreale	0.009	0.052	0.000	0.000
Haplopappus spinulosus	0.005	0.029	0.000	0.000
Heterotheca villosa	0.008	0.048	0.000	0.000
Sphaeralcea coccinea	0.012	0.077	0.000	0.000
Medicago sativa	0.012	0.074	0.000	0.000
Melilotus officinalis	0.000	0.000	0.005	0.028
Oxytropis sericea	0.007	0.042	0.000	0.000
Phlox hoodii	0.011	0.067	0.059	0.260
Plantago major	0.002	0.013	0.000	0.000

Oxytropis sericea	0.007	0.046	0.000	0.000
Potentilla species	0.000	0.000	0.018	0.114
Solanum triflorum	0.000	0.000	0.003	0.012
Taraxacum officinale	0.001	0.005	0.034	0.213
Tragopogon dubius	0.016	0.081	0.000	0.000
Trifolium hybridum	0.028	0.120	0.000	0.000
Vicia americana	0.000	0.000	0.011	0.037
Triticum aestivum	0.004	0.014	0.000	0.000

n = 40

Table B.31. Mean percent ground cover by plant species on the sodded trench zone in 1997 and 1998 at the Manyberries site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron species	0.000	0.000	0.009	0.042
Agropyron dasystachyum	0.028	0.094	0.030	0.134
Agropyron trachycaulum	0.014	0.044	0.062	0.313
Bouteloua gracilis	0.000	0.003	0.000	0.000
Bromus inermis	0.000	0.000	0.002	0.013
Calamagrostis montanensis	0.001	0.005	0.000	0.000
Carex species	0.161	0.224	1.216	1.803
Distichlis stricta	0.001	0.005	0.000	0.000
Festuca hallii	0.418	0.857	1.033	1.246
Festuca idahoensis	0.009	0.033	0.100	0.282
Helictrotrichon hookeri	0.011	0.038	0.241	0.542
Hordeum jubatum	0.012	0.066	0.011	0.071
Koeleria macrantha	0.275	0.317	1.971	2.051
Muhlenbergia species	0.010	0.062	0.000	0.000
Muhlenbergia richardsonis	0.003	0.022	0.072	0.310
Poa pratensis/compressa	0.023	0.141	0.084	0.383
Stipa comata	0.001	0.009	0.000	0.000
Stipa curtiseta	0.050	0.159	0.194	0.657
Stipa viridula	0.001	0.005	0.000	0.000
Agoseris glauca	0.005	0.028	0.000	0.000
Allium cernuum	0.001	0.008	0.000	0.000
Amaranthus albus	0.134	0.844	0.003	0.019
Amaranthus retroflexus	0.000	0.000	0.002	0.014
Androsace septentrionalis	0.010	0.057	0.008	0.031
Anenome species	0.000	0.000	0.006	0.022
Arenarias species	0.000	0.000	0.001	0.003
Artemisia cana	0.000	0.000	0.000	0.000
Artemisia frigida	0.160	0.566	0.041	0.240
Artemisia ludoviciana	0.014	0.072	0.001	0.008
Aster conspicuus	0.000	0.002	0.000	0.000
Astragalus species	0.002	0.009	0.000	0.000
Astragalus pectinatus	0.000	0.003	0.007	0.043
Chenopodium species	0.000	0.000	0.034	0.104
Cirsium vulgare	0.072	0.455	0.023	0.112
Geum triflorum	0.001	0.003	0.000	0.000
Grindelia squarosa	0.021	0.121	0.023	0.142
Gutierrezia sarothrae	0.000	0.000	0.262	1.374
Liatrus punctata	0.024	0.152	0.000	0.000
Linum lewisii	0.001	0.008	0.000	0.000
Melilotus officinalis	0.000	0.000	0.003	0.016
Oxytropis species	0.001	0.006	0.000	0.000

Oxytropis sericea	0.007	0.046	0.000	0.000
Potentilla species	0.000	0.000	0.018	0.114
Solanum triflorum	0.000	0.000	0.003	0.012
Taraxacum officinale	0.001	0.005	0.034	0.213
Tragopogon dubius	0.016	0.081	0.000	0.000
Trifolium hybridum	0.028	0.120	0.000	0.000
Vicia americana	0.000	0.000	0.011	0.037
Triticum aestivum	0.004	0.014	0.000	0.000

n = 40

Table B.32. Mean percent ground cover by plant species on the sodded work zone in 1997 and 1998 at the Manyberries site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron species	0.000	0.000	0.082	0.471
Agropyron dasystachyum	0.071	0.107	0.077	0.271
Agropyron smithii	0.030	0.092	0.684	1.677
Agrostis scabra	0.000	0.000	0.063	0.324
Agropyron trachycaulum	0.105	0.225	0.668	1.289
Bouteloua gracilis	0.000	0.000	0.040	0.253
Bromus inermis	0.006	0.035	0.000	0.000
Calamagrostis montanensis	0.000	0.000	0.002	0.009
Carex species	0.153	0.271	0.601	1.321
Danthonia species	0.006	0.030	0.035	0.221
Danthonia spicatum	0.012	0.069	0.000	0.000
Festuca seedling	0.000	0.000	0.010	0.063
Festuca hallii	0.139	0.223	0.978	1.709
Festuca idahoensis	0.004	0.026	0.000	0.000
Grass seedling	0.001	0.004	0.000	0.000
Helictrotrichon hookeri	0.004	0.026	0.000	0.000
Hordeum jubatum	0.000	0.000	0.223	0.939
Koeleria macrantha	0.080	0.111	0.956	1.746
Oryzopsis hymenoides	0.001	0.005	0.000	0.000
Poa pratensis/compressa	0.007	0.039	0.000	0.000
Stipa comata	0.012	0.071	0.014	0.085
Stipa curtiseta	0.007	0.025	0.464	0.984
Stipa viridula	0.003	0.012	0.045	0.285
Achillea millefolium	0.002	0.013	0.000	0.000
Androsace septentrionalis	0.000	0.000	0.028	0.155
Anenome species	0.000	0.000	0.017	0.065
Anenome patens	0.000	0.000	0.010	0.043
Artemisia cana	0.002	0.009	0.000	0.000
Artemisia frigida	0.026	0.152	0.012	0.064
Artemisia ludoviciana	0.018	0.064	0.063	0.179
Aster ericoides	0.000	0.000	0.045	0.171
Astragalus species	0.002	0.014	0.002	0.009
Astragalus pectinatus	0.009	0.019	0.000	0.000
Astragalus striatus	0.000	0.000	0.035	0.221
Chenopodium species	0.038	0.127	0.159	0.726
Erigeron species	0.000	0.000	0.008	0.028
Gaillardia aristida	0.002	0.011	0.000	0.000
Geum triflorum	0.011	0.061	0.000	0.000
Grindelia squarosa	0.000	0.000	0.024	0.142
Haplopappus spinulosus	0.005	0.030	0.000	0.000
Kochia scoparia	0.000	0.000	0.000	0.000

Lathyrus species	0.000	0.000	0.012	0.029
Liatrus punctata	0.026	0.154	0.000	0.000
Oxytropis sericea	0.001	0.007	0.000	0.000
Phlox hoodii	0.000	0.003	0.000	0.000
Salaola kali	0.006	0.035	0.000	0.000
Solanum triflorum	0.000	0.000	0.092	0.569
Solidago missouriensis	0.000	0.000	0.019	0.111
Stellaria species	0.000	0.000	0.006	0.038
Symphoricarpos occidentalis	0.000	0.000	0.006	0.040
Thermopsis rhombifolia	0.001	0.008	0.000	0.000
Trifolium hybridum	0.001	0.008	0.000	0.000
Trifolium pratense	0.007	0.030	0.000	0.000
Vicia americana	0.000	0.000	0.026	0.060
Weed seedling	0.003	0.015	0.000	0.000
Triticum aestivum	0.002	0.007	0.000	0.000

n = 35 1997, n = 40 1998

Table B.33. Mean percent ground cover by zone and parameter in 1997 and 1998 at the Hardisty site.

		1997		1998	
Zone	Ground cover parameter	Mean	SD	Mean	SD
Undisturbed prairie	Live vegetation	9.800	4.156	7.667	2.454
	Litter	86.767	7.342	74.900	29.576
	Bare ground	2.433	6.129	16.767	28.969
	Rock	0.033	0.183	0.133	0.507
	Moss	0.000	0.000	0.000	0.000
	Lichen	0.967	2.076	0.533	1.871
Seeded spoil	Live vegetation	2.540	5.167	5.138	2.812
	Litter	2.967	2.956	5.966	6.355
	Bare ground	93.447	5.803	87.414	7.637
	Rock	1.047	1.117	1.483	1.785
	Moss	0.000	0.000	0.000	0.000
	Lichen	0.000	0.000	0.000	0.000
Seeded trench	Live vegetation	0.527	0.935	5.667	4.373
	Litter	3.923	3.235	4.867	4.431
	Bare ground	94.667	3.401	88.433	5.437
	Rock	0.883	1.101	1.033	1.426
	Moss	0.000	0.000	0.000	0.000
	Lichen	0.000	0.000	0.000	0.000
Seeded work	Live vegetation	0.537	0.714	3.900	1.863
	Litter	2.487	1.882	2.267	2.599
	Bare ground	96.177	2.289	92.600	3.847
	Rock	0.800	0.632	1.233	1.591
	Moss	0.000	0.000	0.000	0.000
	Lichen	0.000	0.000	0.000	0.000
Sodded spoil	Live vegetation	3.646	4.148	6.500	2.556
	Litter	5.685	3.021	12.967	18.167
	Bare ground	89.885	6.109	80.167	18.899
	Rock	0.785	0.700	0.367	0.928
	Moss	0.000	0.000	0.000	0.000
	Lichen	0.000	0.000	0.000	0.000

Table B.33. Mean percent ground cover by zone and parameter in 1997 and 1998 at the Hardisty site. (cont'd)

		1997		1998	
Zone	Ground cover parameter	Mean	SD	Mean	SD
Sodded trench	Live vegetation	5.087	8.940	7.643	3.302
	Litter	11.483	6.742	14.034	20.953
	Bare ground	82.943	7.651	78.000	21.693
	Rock	0.487	0.749	0.536	1.170
	Moss	0.000	0.000	0.000	0.000
	Lichen	0.000	0.000	0.000	0.000
Sodded work	Live vegetation	4.420	8.296	8.767	4.376
	Litter	6.333	3.692	5.100	7.832
	Bare ground	88.64	6.180	85.833	9.105
	Rock	0.610	0.469	0.300	0.702
	Moss	0.000	0.000	0.000	0.000
	Lichen	0.000	0.000	0.000	0.000

n = 30, except sodded spoil n = 26 1997
SD: standard deviation

Table B.34. Mean percent ground cover by zone and parameter in 1997 and 1998 at the Manyberries site.

		1997		1998	
Zone	Ground cover parameter	Mean	SD	Mean	SD
Undisturbed prairie	Live vegetation	7.617	3.614	9.700	7.217
	Litter	92.233	3.550	69.733	33.089
	Bare ground	0.007	0.025	5.033	16.697
	Rock	0.000	0.000	0.400	1.850
	Moss	0.143	0.406	14.900	28.772
	Lichen	0.000	0.000	0.233	0.807
	Straw	0.000	0.000	0.000	0.000
Seeded spoil	Live vegetation	3.103	7.191	8.744	4.459
	Litter	1.213	3.974	11.526	18.207
	Bare ground	68.800	33.373	77.167	19.827
	Rock	0.775	1.509	2.564	6.471
	Moss	0.000	0.000	0.000	0.000
	Lichen	0.000	0.000	0.000	0.000
	Straw	26.110	33.972	0.000	0.000
Seeded trench	Live vegetation	0.246	0.186	7.850	3.207
	Litter	0.179	0.522	34.813	32.614
	Bare ground	31.646	30.826	55.975	31.244
	Rock	0.497	0.951	1.363	2.142
	Moss	0.000	0.000	0.000	0.000
	Lichen	0.000	0.000	0.000	0.000
	Straw	67.431	31.397	0.000	0.000
Seeded work	Live vegetation	1.028	2.102	7.038	4.133
	Litter	0.445	1.066	13.025	22.915
	Bare ground	76.968	29.617	77.763	22.700
	Rock	1.918	5.633	2.175	4.599
	Moss	0.000	0.000	0.000	0.000
	Lichen	0.000	0.000	0.000	0.000
	Straw	19.643	29.719	0.000	0.000

Table B.34. Mean percent ground cover by zone and parameter in 1997 and 1998 at the Manyberries site. (Cont'd)

Zone	Ground cover parameter	1997 Mean	1997 SD	1998 Mean	1998 SD
Sodded spoil	Live vegetation	2.883	2.811	7.880	5.231
	Litter	9.620	19.872	9.900	21.389
	Bare ground	80.280	27.327	80.708	21.229
	Rock	1.663	2.203	1.513	1.803
	Moss	4.200	14.490	0.000	0.000
	Lichen	0.000	0.000	0.000	0.000
	Straw	1.355	7.903	0.000	0.000
Sodded trench	Live vegetation	1.518	1.512	8.400	6.168
	Litter	17.478	25.884	12.775	21.873
	Bare ground	76.853	27.577	78.00	21.327
	Rock	0.655	0.747	0.825	1.243
	Moss	0.100	0.379	0.000	0.000
	Lichen	0.025	0.158	0.000	0.000
	Straw	3.373	11.883	0.000	0.000
Sodded work	Live vegetation	0.744	0.602	7.525	5.809
	Litter	1.368	2.835	1.490	3.742
	Bare ground	88.734	23.719	88.910	7.589
	Rock	0.945	1.441	2.075	4.058
	Moss	0.075	0.474	0.000	0.000
	Lichen	0.000	0.000	0.000	0.000
	Straw	8.135	23.753	0.000	0.000

n = 40 except n = 30 undisturbed prairie, n = 39 1998 seeded spoil and 1997 seeded trench
SD: standard deviation

Table B.35. Percent ground cover by plant species on no the strip/no seed spoil in 1997 and 1998 at the Jenner North site.

Species	1997 Mean	1997 SD	1998 Mean	1998 SD
Agropyron trachycaulum	0.041	0.226	0.020	0.110
Bouteloua gracilis	0.978	1.471	0.825	2.083
Calamagrostis montanensis	0.000	0.000	0.010	0.037
Carex species	0.791	1.360	1.441	1.975
Koeleria macrantha	0.083	0.205	0.142	0.349
Stipa comata	0.191	0.364	0.529	1.063
Stipa curtiseta	0.137	0.749	0.123	0.474
Antennaria parvifolia	0.000	0.000	0.003	0.016
Artemisia frigida	0.484	1.658	0.011	0.058
Artemisia ludoviciana	0.020	0.102	0.000	0.000
Astragalus pectinatus	0.005	0.019	0.000	0.000
Campanula rotundifolia	0.006	0.022	0.025	0.078
Chenopodium species	0.000	0.000	0.001	0.007
Lactuca pulchella	0.000	0.000	0.001	0.007
Lappula species	0.000	0.000	0.033	0.183
Liatris punctata	0.021	0.117	0.000	0.000
Lygodesmia juncea	0.005	0.018	0.013	0.073
Malvacea coccinea	0.010	0.030	0.015	0.068
Salsola kali	0.000	0.000	0.005	0.029
Sisymbrium altissimum	0.000	0.000	0.003	0.015
Vicia americana	0.000	0.000	0.064	0.197

n = 30

Table B.36. Percent ground cover by plant species on no strip/no seed trench in 1997 and 1998 at the Jenner North site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron trachycaulum	0.000	0.000	0.152	0.584
Bouteloua gracilis	0.058	0.144	0.167	0.649
Carex species	0.017	0.042	0.033	0.183
Hordeum jubatum	0.000	0.000	0.200	0.664
Koeleria macrantha	0.007	0.025	0.061	0.232
Oryzopsis hymenoides	0.000	0.000	0.060	0.329
Stipa comata	0.000	0.000	0.028	0.153
Stipa curtiseta	0.000	0.000	0.003	0.018
Amaranthus retroflexus	0.000	0.000	0.033	0.183
Chenopodium species	0.000	0.000	0.147	0.570

n = 30

Table B.37. Percent ground cover by plant species on no strip/no seed work in 1997 and 1998 at the Jenner North site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron trachycaulum	0.009	0.049	0.000	0.000
Bouteloua gracilis	1.902	2.828	1.530	1.953
Calamagrostis montanensis	0.013	0.037	0.005	0.026
Carex species	1.542	1.946	4.244	4.131
Koeleria macrantha	0.403	0.737	0.361	0.541
Stipa comata	0.105	0.299	0.900	1.568
Stipa curtiseta	0.111	0.352	0.276	0.732
Agoseris glauca	0.209	0.711	0.175	0.466
Antennaria parvifolia	0.000	0.000	0.002	0.011
Artemisia frigida	0.004	0.022	0.000	0.000
Artemisia ludoviciana	0.031	0.076	0.116	0.244
Aster ericoides	0.155	0.675	0.000	0.000
Astragalus species	0.002	0.008	0.002	0.011
Astragalus pectinatus	0.008	0.019	0.000	0.000
Campanula rotundifolia	0.115	0.340	0.151	0.400
Chenopodium species	0.000	0.000	0.062	0.321
Gaura coccinea	0.005	0.026	0.000	0.000
Haplopappus spinulosus	0.000	0.000	0.023	0.085
Lactuca pulchella	0.009	0.032	0.074	0.223
Liatris punctata	0.012	0.038	0.008	0.044
Lithospermum arvense	0.000	0.000	0.004	0.022
Lygodesmia juncea	0.128	0.690	0.018	0.058
Malvacea coccinea	0.005	0.015	0.012	0.045
Oxytropis species	0.004	0.022	0.000	0.000
Phlox hoodii	0.002	0.009	0.005	0.026
Sonchus species	0.002	0.013	0.000	0.000
Vicia americana	0.000	0.000	0.078	0.148
Weed seedling	0.002	0.011	0.000	0.000

n = 30

Table B.38. Percent ground cover by plant species on no strip/seed spoil in 1997 and 1998 at the Jenner North site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron trachycaulum	0.076	0.164	0.302	0.779
Bouteloua gracilis	1.399	2.105	1.155	1.372
Calamovilfa longifolia	0.031	0.057	0.106	0.315
Calamagrostis montanensis	0.002	0.010	0.005	0.027
Carex species	0.530	0.648	0.861	1.130
Distichlis stricta	0.088	0.264	0.000	0.000
Festuca ovina	0.000	0.000	0.003	0.010
Grass seedling	0.012	0.032	0.001	0.004
Koeleria macrantha	0.136	0.298	0.103	0.270
Muhlenbergia species	0.005	0.029	0.000	0.000
Poa compressa	0.002	0.007	0.020	0.081
Poa cusickii	0.000	0.000	0.003	0.018
Stipa comata	0.091	0.291	0.496	0.678
Stipa curtiseta	0.048	0.187	0.038	0.163
Stipa viridula	0.010	0.049	0.002	0.011
Amaranthus graecizans	0.000	0.000	0.022	0.084
Amaranthus retroflexus	0.000	0.000	0.009	0.025
Antennaria parvifolia	0.050	0.196	0.073	0.298
Artemisia frigida	0.017	0.049	0.000	0.000
Artemisia ludoviciana	0.011	0.041	0.000	0.000
Aster ericoides	0.005	0.028	0.000	0.000
Astragalus species	0.037	0.134	0.000	0.000
Astragalus striatus	0.000	0.000	0.013	0.052
Chenopodium album	0.000	0.000	0.001	0.004
Cleome serrulata	0.000	0.000	0.007	0.029
Erigeron species	0.000	0.000	0.001	0.007
Heterotheca villosa	0.048	0.150	0.012	0.038
Liatris punctata	0.029	0.132	0.006	0.033
Linum rigidum	0.000	0.000	0.007	0.037
Lithospermum arvense	0.000	0.000	0.047	0.256
Lygodesmia juncea	0.026	0.078	0.033	0.164
Malvacea coccinea	0.000	0.000	0.029	0.095
Orthocarpus luteus	0.039	0.208	0.000	0.000
Oxytropis species	0.001	0.003	0.000	0.000
Phlox hoodii	0.016	0.087	0.006	0.026
Potentilla species	0.025	0.134	0.000	0.000
Solanum triflorum	0.015	0.082	0.001	0.004
Solidago species	0.031	0.169	0.000	0.000
Solidago missouriensis	0.000	0.000	0.007	0.033

n = 29 1997, n = 30 1998

Table B.39. Percent ground cover by plant species on no strip/seed trench in 1997 and 1998 at the Jenner North site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron trachycaulum	0.027	0.041	0.609	0.612
Bouteloua gracilis	0.003	0.015	0.400	1.166
Calamovilfa longifolia	0.009	0.017	0.032	0.118
Carex species	0.012	0.025	0.026	0.070
Distichlis stricta	0.003	0.018	0.000	0.000
Festuca ovina	0.000	0.000	0.033	0.183
Grass seedling	0.008	0.018	0.008	0.024
Koeleria macrantha	0.007	0.012	0.070	0.245
Oryzopsis hymenoides	0.002	0.012	0.029	0.159
Sporobolus species	0.000	0.000	0.021	0.086
Stipa comata	0.002	0.007	0.000	0.000
Stipa viridula	0.004	0.012	0.000	0.000
Aster ericoides	0.000	0.000	0.003	0.016
Chenopodium species	0.000	0.000	0.003	0.018
Chenopodium album	0.000	0.000	0.005	0.027
Solanum triflorum	0.000	0.000	0.013	0.073

n = 30

Table B.40. Percent ground cover by plant species on no strip/seed work in 1997 and 1998 at the Jenner North site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron trachycaulum	0.011	0.030	0.243	1.046
Bouteloua gracilis	1.466	1.903	2.465	3.085
Calamovilfa longifolia	0.003	0.012	0.052	0.196
Calamagrostis montanensis	0.033	0.127	0.029	0.077
Carex species	0.634	0.833	0.980	1.373
Distichlis stricta	0.310	0.639	0.012	0.064
Festuca ovina	0.000	0.000	0.033	0.183
Grass seedling	0.001	0.004	0.000	0.000
Koeleria macrantha	0.188	0.435	0.350	0.459
Oryzopsis hymenoides	0.000	0.000	0.035	0.152
Poa sandbergii	0.000	0.000	0.017	0.091
Stipa comata	0.233	0.800	0.730	1.313
Stipa curtiseta	0.087	0.333	0.332	1.046
Agoseris glauca	0.004	0.022	0.000	0.000
Amaranthus albus	0.002	0.011	0.000	0.000
Amaranthus retroflexus	0.000	0.000	0.009	0.027
Antennaria parvifolia	0.167	0.508	0.032	0.135
Artemisia frigida	0.009	0.033	0.067	0.365
Aster ericoides	0.008	0.045	0.027	0.146
Astragalus striatus	0.000	0.000	0.018	0.069
Chenopodium species	0.002	0.009	0.000	0.000
Comandra umbellata	0.001	0.005	0.000	0.000
Grindelia squarrosa	0.000	0.000	0.154	0.843
Heterotheca villosa	0.028	0.084	0.013	0.071
Lactuca pulchella	0.110	0.439	0.127	0.476
Liatris punctata	0.031	0.106	0.020	0.078
Linum rigidum	0.002	0.010	0.000	0.000
Lithospermum arvense	0.000	0.000	0.004	0.022
Lygodesmia juncea	0.001	0.007	0.087	0.199
Malvacea coccinea	0.003	0.011	0.009	0.034
Oxytropis species	0.082	0.291	0.000	0.000
Phlox hoodii	0.005	0.021	0.012	0.064
Potentilla species	0.028	0.091	0.000	0.000
Ratibida columnifera	0.012	0.063	0.096	0.496

n = 29 1997, n = 30 1998

Table B.41. Percent ground cover by plant species on strip/no seed trench in 1997 and 1998 at the Jenner North site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron trachycaulum	0.000	0.000	0.091	0.285
Bouteloua gracilis	0.147	0.380	0.527	1.634
Calamovilfa longifolia	0.014	0.075	0.033	0.183
Carex species	0.003	0.018	0.000	0.000
Festuca ovina	0.000	0.000	0.022	0.119
Grass seedling	0.000	0.000	0.002	0.006
Oryzopsis hymenoides	0.000	0.000	0.009	0.049
Sporobolus species	0.000	0.000	0.003	0.018
Stipa comata	0.003	0.018	0.000	0.000
Amaranthus graecizans	0.000	0.000	0.036	0.183
Amaranthus retroflexus	0.000	0.000	0.007	0.037
Chamaerhodos nuttallii	0.000	0.000	0.032	0.097
Chenopodium species	0.000	0.000	0.003	0.015
Lappula species	0.000	0.000	0.069	0.302
Liatris punctata	0.013	0.034	0.072	0.365
Lithospermum arvense	0.000	0.000	0.067	0.365
Lygodesmia juncea	0.003	0.018	0.000	0.000
Oxytropis species	0.000	0.000	0.173	0.949
Potentilla species	0.007	0.025	0.000	0.000
Ratibida columnifera	0.003	0.018	0.000	0.000
Scleranthus annuus	0.013	0.073	0.000	0.000
Solanum triflorum	0.000	0.000	0.013	0.073
Weed seedling	0.000	0.000	0.099	0.399

n = 30

Table B.42. Percent ground cover by plant species on strip/no seed work in 1997 and 1998 at the Jenner North site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron trachycaulum	0.000	0.000	0.033	0.149
Bouteloua gracilis	0.214	0.442	0.618	1.402
Calamovilfa longifolia	0.020	0.069	0.000	0.000
Carex species	0.010	0.041	0.043	0.172
Grass seedling	0.000	0.002	0.000	0.000
Koeleria macrantha	0.000	0.000	0.093	0.272
Poa cusickii	0.000	0.000	0.007	0.037
Artemisia frigida	0.004	0.019	0.269	1.460
Chamaerhodos nuttallii	0.000	0.000	0.097	0.331
Chenopodium species	0.000	0.000	0.007	0.037
Liatris punctata	0.018	0.046	0.110	0.404
Lithospermum arvense	0.000	0.000	0.024	0.111
Potentilla species	0.009	0.033	0.000	0.000
Ratibida columnifera	0.000	0.000	0.076	0.416
Salsola kali	0.000	0.000	0.013	0.073
Weed seedling	0.000	0.000	0.047	0.194

n = 29 1997, n = 30 1998

Table B.43. Percent ground cover by plant species on strip/seed spoil in 1997 and 1998 at the Jenner North site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron trachycaulum	0.021	0.036	0.456	1.056
Bouteloua gracilis	1.107	2.587	0.849	1.431
Bromus tectorum	0.001	0.003	0.000	0.000
Calamovilfa longifolia	0.006	0.016	0.276	0.593
Calamagrostis montanensis	0.000	0.000	0.007	0.037
Carex species	0.145	0.353	0.298	0.429
Echinochloa crusgalli	0.031	0.169	0.000	0.000
Festuca ovina	0.000	0.000	0.021	0.065
Grass seedling	0.005	0.012	0.018	0.041
Koeleria macrantha	0.115	0.407	0.027	0.086
Oryzopsis hymenoides	0.000	0.000	0.005	0.029
Sporobolus species	0.000	0.000	0.072	0.325
Stipa comata	0.150	0.479	0.462	1.106
Stipa curtiseta	0.039	0.128	0.000	0.000
Stipa viridula	0.001	0.003	0.010	0.055
Amaranthus species	0.000	0.000	0.002	0.011
Antennaria parvifolia	0.030	0.164	0.000	0.000
Artemisia frigida	0.031	0.117	0.217	0.627
Aster ericoides	0.084	0.460	0.000	0.000
Astragalus species	0.000	0.000	0.058	0.320
Chamaerhodos nuttallii	0.000	0.000	0.007	0.037
Cirsium vulgare	0.570	3.122	0.007	0.037
Gaura species	0.016	0.089	0.000	0.000
Gaura coccinea	0.003	0.018	0.000	0.000
Heterotheca villosa	0.003	0.014	0.000	0.000
Liatris punctata	0.057	0.163	0.007	0.037
Lygodesmia juncea	0.000	0.000	0.007	0.028
Malvacea coccinea	0.000	0.000	0.003	0.018
Phlox hoodii	0.003	0.012	0.008	0.030
Polygonum aviculare	0.000	0.000	0.008	0.046
Potentilla species	0.005	0.023	0.000	0.000
Weed seedling	0.000	0.000	0.003	0.015

n = 30

Table B.44. Percent ground cover by plant species on strip/seed trench in 1997 and 1998 at the Jenner North site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron trachycaulum	0.015	0.042	0.544	0.674
Bouteloua gracilis	0.040	0.187	0.271	0.738
Calamovilfa longifolia	0.017	0.029	0.063	0.213
Carex species	0.001	0.005	0.061	0.246
Echinochloa crusgalli	0.000	0.000	0.023	0.097
Festuca ovina	0.000	0.000	0.069	0.241
Grass seedling	0.001	0.003	0.013	0.031
Hordeum jubatum	0.096	0.366	0.424	1.116
Koeleria macrantha	0.008	0.020	0.028	0.108
Oryzopsis hymenoides	0.000	0.000	0.088	0.315
Poa compressa	0.000	0.001	0.000	0.000
Sporobolus species	0.000	0.000	0.098	0.306
Stipa comata	0.003	0.015	0.000	0.000
Stipa viridula	0.002	0.009	0.061	0.222
Amaranthus species	0.000	0.000	0.010	0.055
Chamaerhodos nuttallii	0.000	0.000	0.008	0.039
Chenopodium species	0.000	0.000	0.040	0.141
Chenopodium album	0.000	0.000	0.008	0.033
Lappula species	0.000	0.000	0.017	0.066
Liatris punctata	0.012	0.042	0.033	0.183
Lygodesmia juncea	0.000	0.000	0.010	0.055
Monolepis nuttalliana	0.010	0.051	0.000	0.000
Oxytropis species	0.007	0.038	0.000	0.000
Potentilla species	0.011	0.058	0.000	0.000
Salsola kali	0.000	0.000	0.023	0.128
Weed seedling	0.000	0.000	0.003	0.018

n = 27 1997, n = 30 1998

Table B.45. Percent ground cover by plant species on strip/seed work in 1997 and 1998 at the Jenner North site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron trachycaulum	0.006	0.017	0.575	1.139
Bouteloua gracilis	0.288	1.001	0.219	0.746
Calamovilfa longifolia	0.024	0.049	0.131	0.439
Carex species	0.005	0.020	0.000	0.000
Festuca ovina	0.000	0.000	0.006	0.033
Grass seedling	0.009	0.016	0.004	0.014
Hordeum jubatum	0.007	0.036	0.677	2.005
Koeleria macrantha	0.008	0.020	0.032	0.106
Oryzopsis hymenoides	0.000	0.000	0.040	0.160
Poa compressa	0.006	0.024	0.000	0.000
Sporobolus species	0.000	0.000	0.032	0.173
Stipa curtiseta	0.000	0.000	0.028	0.149
Stipa viridula	0.001	0.005	0.072	0.193
Amaranthus graecizans	0.000	0.000	0.006	0.030
Amaranthus retroflexus	0.000	0.000	0.000	0.000
Chamaerhodos nuttallii	0.000	0.000	0.002	0.011
Kochia scoparia	0.000	0.000	0.019	0.102
Liatris punctata	0.000	0.000	0.003	0.017
Linum lewisii	0.000	0.000	0.000	0.000
Polygonum species	0.000	0.000	0.050	0.269
Potentilla species	0.008	0.029	0.000	0.000

n = 28 1997, n = 30 1998

Table B.46. Percent ground cover by plant species on undisturbed prairie in 1997 and 1998 at the Jenner North site.

	1997		1998	
Species	Mean	SD	Mean	SD
Bouteloua gracilis	1.256	1.312	1.913	1.530
Calamovilfa longifolia	0.036	0.137	0.011	0.059
Calamagrostis montanensis	0.000	0.000	0.004	0.022
Carex species	0.756	1.213	1.250	2.364
Koeleria macrantha	0.321	0.408	0.224	0.345
Poa sandbergii	0.029	0.133	0.000	0.000
Stipa comata	1.373	1.695	1.073	1.083
Stipa curtiseta	0.000	0.000	0.052	0.279
Agoseris glauca	0.000	0.000	0.050	0.267
Antennaria species	0.083	0.456	0.000	0.000
Antennaria parvifolia	0.264	1.446	0.015	0.066
Artemisia frigida	0.637	2.174	0.024	0.073
Artemisia ludoviciana	0.035	0.192	0.068	0.273
Aster ericoides	0.042	0.158	0.050	0.267
Astragalus species	0.000	0.000	0.019	0.100
Astragalus striatus	0.000	0.000	0.006	0.033
Campanula rotundifolia	0.000	0.000	0.005	0.028
Cerastium arvense	0.000	0.000	0.019	0.100
Equisetum species	0.000	0.000	0.008	0.045
Glycyrrhiza lepidota	0.026	0.099	0.005	0.028
Heterotheca villosa	0.067	0.365	0.000	0.000
Liatris punctata	0.102	0.262	0.012	0.042
Linum lewisii	0.002	0.011	0.000	0.000
Lygodesmia juncea	0.006	0.023	0.000	0.000
Malvacea coccinea	0.020	0.068	0.010	0.040
Opuntia polyacantha	0.301	1.647	0.000	0.000
Penstemon species	0.000	0.000	0.025	0.134
Phlox hoodii	0.000	0.000	0.030	0.092
Solidago missouriensis	0.000	0.000	0.004	0.022
Tragopogon dubius	0.000	0.000	0.014	0.046
Vicia americana	0.000	0.000	0.017	0.070

n = 30 1997, n = 29 1998

Table B.47. Plant species density number per 0.1 meter square on no strip/no seed spoil in 1997 and 1998 at the Jenner North site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron trachycaulum	0.067	0.365	0.067	0.365
Bouteloua gracilis	4.000	6.762	1.200	2.483
Calamagrostis montanensis	0.000	0.000	0.167	0.648
Carex species	15.433	17.743	16.533	21.045
Koeleria macrantha	1.000	1.965	0.867	2.097
Stipa comata	1.367	2.484	1.033	2.189
Stipa curtiseta	0.167	0.913	0.267	1.015
Antennaria parvifolia	0.000	0.000	0.033	0.183
Artemisia frigida	0.267	0.785	0.033	0.183
Artemisia ludoviciana	0.200	0.925	0.000	0.000
Astragalus pectinatus	0.267	0.980	0.000	0.000
Campanula rotundifolia	0.067	0.254	0.600	2.920
Chenopodium species	0.000	0.000	0.033	0.183
Lactuca pulchella	0.000	0.000	0.033	0.183
Lappula species	0.000	0.000	0.033	0.183
Liatris punctata	0.233	1.278	0.000	0.000
Lygodesmia juncea	0.200	0.805	0.033	0.183
Malvacea coccinea	0.267	0.691	0.067	0.254
Salsola kali	0.000	0.000	0.033	0.183
Sisymbrium altissimum	0.000	0.000	0.033	0.183
Vicia americana	0.000	0.000	0.667	1.493

n = 30

Table B.48. Plant species density number per 0.1 meter square on no strip/no seed trench in 1997 and 1998 at the Jenner North site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron trachycaulum	0.000	0.000	0.133	0.346
Bouteloua gracilis	0.167	0.379	0.067	0.254
Carex species	0.367	0.890	0.067	0.365
Hordeum jubatum	0.000	0.000	0.100	0.305
Koeleria macrantha	0.067	0.254	0.067	0.254
Oryzopsis hymenoides	0.000	0.000	0.133	0.730
Stipa comata	0.000	0.000	0.033	0.183
Stipa curtiseta	0.000	0.000	0.033	0.183
Amaranthus retroflexus	0.000	0.000	0.033	0.183
Chenopodium species	0.000	0.000	0.333	0.922

n = 30

Table B.49. Plant species density number per 0.1 meter square on no strip/no seed work in 1997 and 1998 at the Jenner North site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron trachycaulum	0.033	0.183	0.000	0.000
Bouteloua gracilis	4.067	5.252	2.867	3.617
Calamagrostis montanensis	0.233	0.679	0.033	0.183
Carex species	25.133	24.773	34.067	17.302
Koeleria macrantha	5.333	10.283	1.333	2.264
Stipa comata	1.733	4.719	1.600	2.660
Stipa curtiseta	0.367	0.809	0.300	0.794
Agoseris glauca	1.967	4.716	1.167	3.163
Antennaria parvifolia	0.000	0.000	0.033	0.183
Artemisia frigida	0.067	0.365	0.000	0.000
Artemisia ludoviciana	0.567	1.478	0.767	1.478
Aster ericoides	0.500	1.676	0.000	0.000
Astragalus species	0.067	0.365	0.100	0.548
Astragalus pectinatus	0.267	0.583	0.000	0.000
Campanula rotundifolia	1.467	3.674	1.200	3.253
Chenopodium species	0.000	0.000	0.100	0.305
Gaura coccinea	0.033	0.183	0.000	0.000
Haplopappus spinulosus	0.000	0.000	0.267	0.980
Lactuca pulchella	0.133	0.571	0.233	0.626
Liatris punctata	0.167	0.592	0.033	0.183
Lithospermum arvense	0.000	0.000	0.033	0.183
Lygodesmia juncea	0.167	0.531	0.200	0.664
Malvacea coccinea	0.133	0.346	0.067	0.254
Oxytropis species	0.033	0.183	0.000	0.000
Phlox hoodii	0.033	0.183	0.067	0.254
Sonchus species	0.067	0.365	0.000	0.000
Vicia americana	0.000	0.000	1.133	2.013
Weed seedling	0.033	0.183	0.000	0.000

n = 30

Table B.50. Plant species density number per 0.1 meter square on no strip/seed spoil in 1997 and 1998 at the Jenner North site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron trachycaulum	1.333	1.900	0.800	1.919
Bouteloua gracilis	2.533	3.411	1.967	2.684
Calamovilfa longifolia	0.500	0.820	0.367	0.809
Calamagrostis montanensis	0.033	0.183	0.033	0.183
Carex species	11.067	13.764	9.733	11.826
Distichlis stricta	0.200	0.610	0.000	0.000
Festuca ovina	0.000	0.000	0.067	0.254
Grass seedling	1.300	2.261	0.033	0.183
Koeleria macrantha	0.667	0.922	0.300	0.837
Poa compressa	0.167	0.592	0.067	0.254
Poa cusickii	0.000	0.000	0.033	0.183
Stipa comata	0.567	1.357	0.967	1.326
Stipa curtiseta	0.100	0.403	0.133	0.571
Stipa viridula	0.100	0.305	0.033	0.183
Amaranthus graecizans	0.000	0.000	0.200	0.925
Amaranthus retroflexus	0.000	0.000	0.967	4.206
Antennaria parvifolia	0.233	0.898	0.067	0.254
Artemisia frigida	0.267	0.691	0.000	0.000
Artemisia ludoviciana	0.267	0.980	0.000	0.000
Aster ericoides	0.033	0.183	0.000	0.000
Astragalus species	0.233	0.774	0.000	0.000
Astragalus striatus	0.000	0.000	0.267	0.907
Chenopodium album	0.000	0.000	0.033	0.183
Cleome serrulata	0.000	0.000	0.067	0.254
Erigeron species	0.000	0.000	0.067	0.365
Heterotheca villosa	0.000	0.000	0.100	0.305
Liatris punctata	0.300	1.022	0.033	0.183
Linum rigidum	0.000	0.000	0.033	0.183
Lithospermum arvense	0.000	0.000	0.033	0.183
Lygodesmia juncea	0.267	0.691	0.100	0.305
Malvacea coccinea	0.000	0.000	0.100	0.305
Orthocarpus luteus	0.033	0.183	0.000	0.000
Oxytropis species	0.033	0.183	0.000	0.000
Penstemon species	0.000	0.000	0.000	0.000
Phlox hoodii	0.033	0.183	0.067	0.254
Solanum triflorum	0.033	0.183	0.033	0.183
Solidago missouriensis	0.000	0.000	0.100	0.403

n = 30

Table B.51. Plant species density number per 0.1 meter square on no strip/seed trench in 1997 and 1998 at the Jenner North site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron trachycaulum	0.833	1.147	1.500	1.196
Bouteloua gracilis	0.100	0.403	0.200	0.551
Calamovilfa longifolia	0.400	0.675	0.133	0.434
Carex species	0.733	1.552	0.300	0.837
Distichlis stricta	0.033	0.183	0.000	0.000
Festuca ovina	0.000	0.000	0.067	0.365
Grass seedling	2.700	2.926	0.467	1.167
Hordeum jubatum	0.000	0.000	0.000	0.000
Koeleria macrantha	0.467	0.819	0.133	0.434
Muhlenbergia species	0.100	0.548	0.000	0.000
Oryzopsis hymenoides	0.033	0.183	0.033	0.183
Sporobolus species	0.000	0.000	0.067	0.254
Stipa comata	0.067	0.254	0.000	0.000
Stipa viridula	0.267	0.691	0.000	0.000
Aster ericoides	0.000	0.000	0.033	0.183
Chenopodium species	0.000	0.000	0.033	0.183
Chenopodium album	0.000	0.000	0.033	0.183
Solanum triflorum	0.000	0.000	0.033	0.183

n = 30

Table B.52. Plant species density number per 0.1 meter square on no strip/seed work in 1997 and 1998 at the Jenner North site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron trachycaulum	0.300	0.794	0.233	0.971
Bouteloua gracilis	3.733	4.209	2.300	2.769
Calamovilfa longifolia	0.067	0.254	0.167	0.592
Calamagrostis montanensis	0.167	0.592	0.333	1.028
Carex species	16.867	16.023	10.700	12.416
Distichlis stricta	0.767	1.612	0.033	0.183
Festuca ovina	0.000	0.000	0.067	0.365
Grass seedling	0.300	0.915	0.000	0.000
Koeleria macrantha	0.900	1.863	1.000	1.287
Oryzopsis hymenoides	0.000	0.000	0.067	0.254
Poa sandbergii	0.000	0.000	0.033	0.183
Stipa comata	0.367	1.066	1.033	1.866
Stipa curtiseta	0.133	0.571	0.533	1.852
Agoseris glauca	0.033	0.183	0.000	0.000
Amaranthus albus	0.033	0.183	0.000	0.000
Amaranthus retroflexus	0.000	0.000	0.133	0.346
Antennaria parvifolia	0.867	2.636	0.067	0.254
Artemisia frigida	0.133	0.346	0.033	0.183
Aster ericoides	0.000	0.000	0.067	0.365
Astragalus striatus	0.000	0.000	0.233	1.104
Chenopodium species	0.067	0.365	0.000	0.000
Comandra umbellata	0.067	0.365	0.000	0.000
Grindelia squarrosa	0.000	0.000	0.033	0.183
Heterotheca villosa	0.167	0.461	0.033	0.183
Lactuca pulchella	0.367	1.066	0.333	1.155
Liatris punctata	0.133	0.434	0.100	0.403
Linum rigidum	0.033	0.183	0.000	0.000
Lithospermum arvense	0.000	0.000	0.033	0.183
Lygodesmia juncea	0.033	0.183	0.367	0.669
Malvacea coccinea	0.067	0.254	0.067	0.254
Oxytropis species	0.467	1.167	0.000	0.000
Penstemon species	0.000	0.000	0.000	0.000
Phlox hoodii	0.067	0.254	0.067	0.365
Potentilla species	0.100	0.305	0.000	0.000
Ratibida columnifera	0.033	0.183	0.100	0.403

n = 30

Table B.53. Plant species density number per 0.1 meter square on strip/no seed trench in 1997 and 1998 at the Jenner North site.

Species	1997 Mean	 SD	1998 Mean	 SD
Agropyron trachycaulum	0.000	0.000	0.167	0.531
Bouteloua gracilis	0.333	0.711	0.133	0.346
Calamovilfa longifolia	0.033	0.183	0.033	0.183
Carex species	0.167	0.913	0.000	0.000
Festuca ovina	0.000	0.000	0.033	0.183
Grass seedling	0.067	0.365	0.100	0.305
Oryzopsis hymenoides	0.000	0.000	0.033	0.183
Sporobolus species	0.000	0.000	0.033	0.183
Stipa comata	0.033	0.183	0.000	0.000
Amaranthus graecizans	0.000	0.000	0.067	0.254
Amaranthus retroflexus	0.000	0.000	0.033	0.183
Chamaerhodos nuttallii	0.000	0.000	0.133	0.346
Chenopodium species	0.000	0.000	0.100	0.548
Lappula species	0.000	0.000	0.100	0.403
Liatris punctata	0.167	0.379	0.067	0.254
Lithospermum arvense	0.000	0.000	0.033	0.183
Malvacea coccinea	0.033	0.183	0.000	0.000
Oxytropis species	0.000	0.000	0.033	0.183
Potentilla species	0.067	0.254	0.000	0.000
Ratibida columnifera	0.033	0.183	0.000	0.000
Scleranthus annuus	0.033	0.183	0.000	0.000
Solanum triflorum	0.000	0.000	0.033	0.183
Weed seedling	0.000	0.000	0.100	0.403

n = 30

Table B.54. Plant species density number per 0.1 meter square strip/no seed work in 1997 and 1998 at the Jenner North site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron trachycaulum	0.000	0.000	0.067	0.254
Bouteloua gracilis	0.500	1.009	0.300	0.535
Calamovilfa longifolia	0.133	0.346	0.000	0.000
Carex species	0.233	0.898	0.167	0.747
Festuca ovina	0.000	0.000	0.033	0.183
Grass seedling	0.033	0.183	0.000	0.000
Koeleria macrantha	0.000	0.000	0.133	0.346
Poa cusickii	0.000	0.000	0.033	0.183
Artemisia frigida	0.067	0.254	0.067	0.254
Chamaerhodos nuttallii	0.000	0.000	0.100	0.305
Chenopodium species	0.000	0.000	0.033	0.183
Liatris punctata	0.200	0.484	0.100	0.305
Lithospermum arvense	0.000	0.000	0.067	0.254
Potentilla species	0.067	0.254	0.000	0.000
Ratibida columnifera	0.000	0.000	0.033	0.183
Salsola kali	0.000	0.000	0.033	0.183
Weed seedling	0.000	0.000	0.100	0.403

n = 30

Table B.55. Plant species density number per 0.1 meter square strip/seed spoil in 1997 and 1998 at the Jenner North site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron trachycaulum	1.000	2.150	0.667	1.241
Bouteloua gracilis	2.500	5.185	0.867	1.306
Bromus tectorum	0.033	0.183	0.000	0.000
Calamovilfa longifolia	0.400	0.894	0.600	1.354
Calamagrostis montanensis	0.000	0.000	0.133	0.730
Carex species	5.100	8.719	4.733	7.372
Echinochloa crusgalli	0.033	0.183	0.000	0.000
Festuca ovina	0.000	0.000	0.133	0.346
Grass seedling	1.833	3.395	0.367	0.890
Koeleria macrantha	1.000	1.838	0.133	0.434
Oryzopsis hymenoides	0.000	0.000	0.033	0.183
Poa compressa	0.033	0.183	0.000	0.000
Sporobolus species	0.000	0.000	0.100	0.403
Stipa comata	0.767	1.524	0.933	1.837
Stipa curtiseta	0.133	0.346	0.000	0.000
Stipa viridula	0.033	0.183	0.067	0.365
Amaranthus species	0.000	0.000	0.033	0.183
Antennaria parvifolia	0.033	0.183	0.000	0.000
Artemisia frigida	0.067	0.254	0.267	0.828
Artemisia ludoviciana	0.000	0.000	0.000	0.000
Aster ericoides	0.100	0.548	0.000	0.000
Astragalus species	0.000	0.000	0.033	0.183
Chamaerhodos nuttallii	0.000	0.000	0.033	0.183
Cirsium vulgare	0.033	0.183	0.033	0.183
Gaura species	0.033	0.183	0.000	0.000
Gaura coccinea	0.033	0.183	0.000	0.000
Heterotheca villosa	0.033	0.183	0.000	0.000
Liatris punctata	0.300	0.651	0.033	0.183
Lygodesmia juncea	0.000	0.000	0.067	0.254
Malvacea coccinea	0.000	0.000	0.033	0.183
Phlox hoodii	0.100	0.403	0.133	0.434
Polygonum aviculare	0.000	0.000	0.033	0.183
Weed seedling	0.000	0.000	0.033	0.183

n = 30

Table B.56. Plant species density number per 0.1 meter square strip/seed trench in 1997 and 1998 at the Jenner North site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron trachycaulum	0.400	1.248	0.967	1.159
Bouteloua gracilis	0.067	0.254	0.133	0.346
Calamovilfa longifolia	0.400	0.563	0.100	0.305
Carex species	0.100	0.403	0.333	1.322
Echinochloa crusgalli	0.000	0.000	0.067	0.254
Festuca ovina	0.000	0.000	0.133	0.434
Grass seedling	2.933	4.770	0.467	0.937
Hordeum jubatum	0.100	0.305	0.167	0.461
Koeleria macrantha	0.333	0.711	0.067	0.254
Oryzopsis hymenoides	0.000	0.000	0.133	0.346
Poa compressa	0.033	0.183	0.000	0.000
Sporobolus species	0.000	0.000	0.100	0.305
Stipa comata	0.033	0.183	0.000	0.000
Stipa viridula	0.033	0.183	0.100	0.305
Amaranthus species	0.000	0.000	0.033	0.183
Chamaerhodos nuttallii	0.000	0.000	0.067	0.254
Chenopodium species	0.000	0.000	0.200	0.551
Chenopodium album	0.000	0.000	0.067	0.254
Lappula species	0.000	0.000	0.067	0.254
Liatris punctata	0.200	0.761	0.100	0.548
Lygodesmia juncea	0.000	0.000	0.033	0.183
Oxytropis species	0.033	0.183	0.000	0.000
Potentilla species	0.067	0.254	0.000	0.000
Salsola kali	0.000	0.000	0.033	0.183
Weed seedling	0.000	0.000	0.033	0.183

n = 30

Table B.57. Plant species density number per 0.1 meter square strip/seed work in 1997 and 1998 at the Jenner North site.

Species	1997 Mean	1997 SD	1998 Mean	1998 SD
Agropyron trachycaulum	0.333	0.884	0.667	0.994
Bouteloua gracilis	0.300	0.877	0.100	0.305
Calamovilfa longifolia	0.633	1.098	0.167	0.461
Carex species	0.167	0.648	0.000	0.000
Festuca ovina	0.000	0.000	0.033	0.183
Grass seedling	2.967	4.627	0.333	0.959
Hordeum jubatum	0.033	0.183	0.167	0.461
Koeleria macrantha	0.333	0.758	0.100	0.305
Oryzopsis hymenoides	0.000	0.000	0.100	0.305
Poa compressa	0.100	0.305	0.000	0.000
Stipa comata	0.033	0.183	0.000	0.000
Stipa curtiseta	0.000	0.000	0.067	0.365
Stipa viridula	0.033	0.183	0.133	0.346
Amaranthus graecizans	0.000	0.000	0.067	0.365
Chamaerhodos nuttallii	0.000	0.000	0.033	0.183
Kochia scoparia	0.000	0.000	0.033	0.183
Liatris punctata	0.000	0.000	0.033	0.183
Polygonum species	0.000	0.000	0.033	0.183
Potentilla species	0.100	0.403	0.000	0.000

n = 30

Table B.58. Plant species density number per 0.1 meter square in the control in 1997 and 1998 at the Jenner North site.

	1997		1998	
Species	Mean	SD	Mean	SD
Bouteloua gracilis	8.467	7.152	4.033	3.102
Calamovilfa longifolia	0.567	2.161	0.167	0.913
Calamagrostis montanensis	0.000	0.000	0.033	0.183
Carex species	12.467	15.817	18.733	17.304
Koeleria macrantha	3.067	4.093	1.100	1.768
Muhlenbergia species	0.000	0.000	0.100	0.548
Poa sandbergii	0.433	2.029	0.000	0.000
Stipa comata	5.900	3.800	2.767	2.555
Stipa curtiseta	0.000	0.000	0.167	0.913
Stipa viridula	0.000	0.000	0.133	0.730
Agoseris glauca	0.000	0.000	0.233	1.278
Antennaria species	0.100	0.548	0.000	0.000
Antennaria parvifolia	0.233	1.278	0.067	0.254
Artemisia frigida	0.233	0.626	0.100	0.305
Artemisia ludoviciana	0.133	0.730	0.467	1.479
Aster ericoides	0.433	1.569	0.167	0.913
Astragalus species	0.000	0.000	0.133	0.507
Astragalus striatus	0.000	0.000	0.367	2.008
Campanula rotundifolia	0.000	0.000	0.167	0.648
Cerastium arvense	0.000	0.000	0.233	1.278
Equisetum species	0.000	0.000	0.300	1.643
Glycyrrhiza lepidota	0.167	0.648	0.033	0.183
Heterotheca villosa	0.033	0.183	0.000	0.000
Liatris punctata	0.467	1.224	0.133	0.434
Linum lewisii	0.067	0.365	0.000	0.000
Lygodesmia juncea	0.100	0.403	0.000	0.000
Malvacea coccinea	0.167	0.461	0.067	0.254
Opuntia polyacantha	0.100	0.548	0.000	0.000
Penstemon species	0.000	0.000	0.067	0.365
Phlox hoodii	0.000	0.000	0.267	0.944
Solidago missouriensis	0.000	0.000	0.433	2.192
Tragopogon dubius	0.000	0.000	0.200	0.610
Vicia americana	0.000	0.000	0.167	0.531

n = 30

Table B.59. Percent ground cover by plant species on the no strip/no seed spoil in 1997 and 1998 at the Jenner South site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	0.069	0.173	1.253	1.999
Agropyron smithii	0.042	0.098	0.428	0.897
Agropyron trachycaulum	0.001	0.007	0.000	0.000
Bouteloua gracilis	0.217	0.369	0.585	0.726
Calamagrostis montanensis	0.025	0.049	0.060	0.118
Carex species	0.123	0.183	0.205	0.267
Koeleria macrantha	0.281	0.485	0.292	0.459
Poa sandbergii	0.105	0.280	0.085	0.380
Stipa comata	0.431	0.814	0.659	0.889
Stipa curtiseta	0.490	1.036	0.583	1.340
Amaranthus graecizans	0.000	0.000	0.001	0.004
Amaranthus retroflexus	0.000	0.000	0.014	0.076
Anemone species	0.056	0.193	0.048	0.236
Artemisia frigida	0.032	0.157	0.008	0.027
Chenopodium species	0.000	0.000	0.014	0.066
Haplopappus spinulosus	0.033	0.183	0.000	0.000
Lappula species	0.000	0.000	0.001	0.008
Malvacea coccinea	0.026	0.040	0.099	0.208
Phlox hoodii	0.137	0.279	0.075	0.191
Thermopsis rhombifolia	0.000	0.000	0.004	0.019
Weed seedling	0.002	0.009	0.000	0.000

n = 30 1997, n = 28 1998

Table B.60. Percent ground cover by plant species on no strip/no seed trench in 1997 and 1998 at the Jenner South site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	0.000	0.000	0.033	0.183
Agropyron smithii	0.000	0.000	0.249	0.672
Agropyron trachycaulum	0.000	0.000	0.052	0.274
Poa sandbergii	0.000	0.000	0.050	0.274
Amaranthus graecizans	0.000	0.000	0.057	0.203
Amaranthus retroflexus	0.000	0.000	0.086	0.218
Artemisia frigida	0.000	0.000	1.013	4.006
Chenopodium species	0.000	0.000	0.052	0.201
Lappula species	0.000	0.000	0.400	2.191
Medicago sativa	0.000	0.000	0.233	0.971
Polygonum aviculare	0.000	0.000	0.105	0.575
Sisymbrium altissimum	0.000	0.000	0.087	0.477
Solanum triflorum	0.000	0.000	0.020	0.108

n = 30

Table B.61. Percent ground cover by plant species on no strip/no seed work in 1997 and 1998 at the Jenner South site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	0.033	0.096	1.009	1.772
Agropyron smithii	0.083	0.161	0.304	0.774
Bouteloua gracilis	0.696	1.208	1.019	2.406
Calamagrostis montanensis	0.017	0.044	0.072	0.144
Carex species	0.132	0.163	0.250	0.326
Festuca ovina	0.000	0.000	0.040	0.219
Koeleria macrantha	0.167	0.275	0.640	0.809
Poa sandbergii	0.049	0.141	0.127	0.233
Stipa comata	0.247	0.517	1.298	2.521
Stipa curtiseta	0.293	0.733	0.464	0.898
Stipa viridula	0.004	0.022	0.000	0.000
Achillea millefolium	0.205	1.125	0.000	0.000
Amaranthus graecizans	0.000	0.000	0.002	0.011
Amaranthus retroflexus	0.000	0.000	0.014	0.077
Anemone species	0.000	0.000	0.104	0.469
Anemone patens	0.032	0.166	0.000	0.000
Artemisia frigida	0.094	0.453	0.091	0.346
Chenopodium species	0.000	0.000	0.002	0.013
Chenopodium album	0.000	0.000	0.008	0.046
Malvacea coccinea	0.017	0.042	0.221	0.456
Opuntia polyacantha	0.002	0.013	0.000	0.000
Phlox hoodii	0.008	0.023	0.008	0.030

n = 30

Table B.62. Percent ground cover by plant species on no strip/seed spoil in 1997 and 1998 at the Jenner South site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	0.048	0.139	1.180	1.992
Agropyron smithii	0.327	0.591	1.586	1.621
Agropyron trachycaulum	0.000	0.000	0.059	0.171
Bouteloua gracilis	0.447	1.040	1.428	2.251
Calamagrostis montanensis	0.012	0.041	0.197	0.490
Carex species	0.084	0.130	1.166	1.688
Koeleria macrantha	0.185	0.644	0.390	0.592
Muhlenbergia species	0.000	0.000	0.004	0.020
Poa canbyi	0.000	0.000	0.004	0.022
Poa compressa	0.000	0.000	0.053	0.250
Poa pratensis	0.000	0.000	0.011	0.060
Poa sandbergii	0.185	0.509	0.220	0.374
Stipa comata	0.059	0.147	0.079	0.250
Stipa curtiseta	0.088	0.379	0.661	1.381
Stipa viridula	0.003	0.016	0.000	0.000
Amaranthus retroflexus	0.000	0.000	0.012	0.048
Anemone patens	0.007	0.026	0.076	0.287
Arenaria species	0.000	0.000	0.002	0.011
Artemisia canadensis	0.035	0.192	0.000	0.000
Artemisia ludoviciana	0.013	0.066	0.082	0.268
Aster ericoides	0.000	0.000	0.005	0.029
Astragalus pectinatus	0.005	0.019	0.000	0.000
Chenopodium species	0.000	0.000	0.001	0.004
Lappula species	0.000	0.000	0.003	0.018
Phlox hoodii	0.001	0.005	0.094	0.264
Thermopsis rhombifolia	0.000	0.001	0.002	0.011
Vicia americana	0.000	0.000	0.019	0.055

n = 30

Table B.63. Percent ground cover by plant species on no strip/seed trench in 1997 and 1998 at the Jenner South site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron seedling	0.001	0.004	0.000	0.000
Agropyron species	0.003	0.018	0.000	0.000
Agropyron dasystachyum	0.003	0.018	0.418	1.106
Agropyron smithii	0.000	0.000	0.735	1.733
Agropyron trachycaulum	0.004	0.019	0.723	1.714
Bouteloua gracilis	0.002	0.009	0.000	0.000
Festuca seedling	0.000	0.002	0.000	0.000
Festuca ovina	0.000	0.000	0.016	0.082
Grass seedling	0.000	0.000	0.003	0.015
Hordeum jubatum	0.000	0.000	0.163	0.635
Koeleria macrantha	0.018	0.043	0.005	0.029
Poa species	0.000	0.000	0.003	0.016
Poa sandbergii	0.000	0.000	0.123	0.438
Stipa curtiseta	0.000	0.000	0.005	0.026
Stipa viridula	0.002	0.009	0.118	0.494
Amaranthus species	0.000	0.000	0.003	0.016
Amaranthus graecizans	0.000	0.000	0.030	0.115
Amaranthus retroflexus	0.000	0.000	0.048	0.149
Artemisia frigida	0.000	0.000	0.007	0.037
Chenopodium species	0.000	0.000	0.145	0.416
Cirsium species	0.000	0.000	0.005	0.027
Descurainia sophia	0.000	0.000	0.006	0.030
Phlox hoodii	0.000	0.000	0.023	0.128
Portulaca oleracea	0.000	0.000	0.045	0.201
Sisymbrium altissimum	0.000	0.000	0.031	0.166
Solanum triflorum	0.000	0.000	0.014	0.077
Vicia americana	0.000	0.000	0.003	0.018
Weed seedling	0.000	0.000	0.018	0.076

n = 30

Table B.64. Percent ground cover by plant species on no strip/seed work in 1997 and 1998 at the Jenner South site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron seedling	0.001	0.002	0.000	0.000
Agropyron dasystachyum	0.072	0.181	0.697	1.344
Agropyron smithii	0.066	0.165	0.957	1.364
Agropyron trachycaulum	0.001	0.006	0.168	0.406
Bouteloua gracilis	0.685	1.226	1.161	1.486
Calamagrostis montanensis	0.007	0.020	0.122	0.266
Carex species	0.411	0.578	0.701	0.717
Festuca species	0.001	0.004	0.000	0.000
Festuca ovina	0.000	0.000	0.023	0.128
Koeleria macrantha	0.179	0.402	0.197	0.452
Poa sandbergii	0.018	0.053	0.263	0.461
Stipa comata	0.056	0.179	1.675	4.510
Stipa curtiseta	0.111	0.317	0.901	1.873
Stipa viridula	0.004	0.014	0.059	0.321
Amaranthus graecizans	0.000	0.000	0.040	0.126
Amaranthus retroflexus	0.000	0.000	0.004	0.014
Anemone species	0.011	0.060	0.059	0.224
Anemone patens	0.016	0.088	0.048	0.164
Arnica fulgens	0.000	0.000	0.005	0.026
Artemisia frigida	0.001	0.006	0.029	0.097
Artemisia ludoviciana	0.000	0.000	0.020	0.110
Aster laevis	0.000	0.000	0.009	0.034
Astragalus pectinatus	0.002	0.006	0.000	0.000
Chenopodium species	0.000	0.000	0.016	0.053
Kochia scoparia	0.007	0.040	0.000	0.000
Lappula species	0.000	0.000	0.004	0.020
Malvacea coccinea	0.012	0.039	0.064	0.296
Phlox hoodii	0.000	0.000	0.054	0.125
Portulaca oleracea	0.000	0.000	0.001	0.005
Solidago missouriensis	0.019	0.102	0.000	0.000
Thermopsis rhombifolia	0.000	0.000	0.031	0.164
Vicia americana	0.000	0.000	0.038	0.141
Weed seedling	0.000	0.000	0.005	0.018
Zygadenus gramineus	0.001	0.007	0.000	0.000

n = 30

Table B.65. Percent ground cover by plant species on strip/no seed spoil in 1997 and 1998 at the Jenner South site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	0.171	0.307	0.931	1.387
Agropyron smithii	0.184	0.220	0.708	1.107
Agropyron trachycaulum	0.000	0.000	0.374	1.489
Bouteloua gracilis	0.254	0.565	0.952	1.283
Calamagrostis montanensis	0.027	0.054	0.007	0.031
Carex species	0.761	1.087	0.675	1.326
Festuca ovina	0.000	0.000	0.015	0.067
Koeleria macrantha	0.186	0.266	0.343	0.534
Poa species	0.002	0.009	0.000	0.000
Poa sandbergii	0.194	0.623	0.031	0.095
Stipa comata	0.377	0.806	1.249	1.862
Stipa curtiseta	0.069	0.152	0.011	0.049
Amaranthus retroflexus	0.000	0.000	0.273	0.571
Anemone species	0.009	0.025	0.000	0.000
Anemone patens	0.002	0.009	0.091	0.339
Artemisia frigida	0.014	0.039	0.727	2.575
Artemisia ludoviciana	0.000	0.000	0.045	0.201
Chenopodium species	0.000	0.000	0.084	0.214
Descurainia sophia	0.000	0.000	0.014	0.063
Lappula species	0.000	0.000	0.120	0.537
Malvacea coccinea	0.014	0.041	0.125	0.373
Phlox hoodii	0.017	0.047	0.015	0.046
Polygonum aviculare	0.000	0.000	0.031	0.125
Rosa species	0.001	0.004	0.035	0.157
Salsola kali	0.000	0.000	0.005	0.022
Solanum triflorum	0.000	0.000	0.014	0.063
Symphoricarpos albus	0.003	0.010	0.000	0.000
Symphoricarpos occidentalis	0.000	0.000	0.222	0.643
Thermopsis rhombifolia	0.007	0.022	0.030	0.094
Vicia americana	0.000	0.000	0.025	0.112
Zygademus species	0.002	0.009	0.000	0.000

n = 20

Table B.66. Percent ground cover by plant species on strip/no seed trench in 1997 and 1998 at the Jenner South site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	0.000	0.000	0.178	0.796
Agropyron smithii	0.000	0.000	0.005	0.022
Agropyron trachycaulum	0.000	0.000	0.162	0.436
Bouteloua gracilis	0.026	0.093	0.164	0.622
Calamovilfa longifolia	0.000	0.000	0.079	0.214
Carex species	0.001	0.003	0.160	0.413
Festuca ovina	0.000	0.000	0.090	0.402
Hordeum jubatum	0.000	0.000	0.048	0.212
Koeleria macrantha	0.000	0.000	0.030	0.134
Poa species	0.000	0.000	0.009	0.040
Stipa comata	0.000	0.000	0.020	0.089
Stipa viridula	0.000	0.000	0.015	0.056
Amaranthus graecizans	0.084	0.332	0.000	0.000
Amaranthus retroflexus	0.000	0.000	0.797	1.282
Artemisia frigida	0.017	0.069	0.995	1.985
Astragalus pectinatus	0.006	0.024	0.000	0.000
Chenopodium species	0.000	0.000	0.065	0.082
Chenopodium album	0.000	0.000	0.020	0.087
Lappula species	0.000	0.000	0.128	0.570
Malvacea coccinea	0.000	0.000	0.003	0.013
Rosa species	0.014	0.052	0.000	0.000
Symphoricarpos albus	0.008	0.021	0.000	0.000
Symphoricarpos occidentalis	0.000	0.000	0.056	0.117
Thermopsis rhombifolia	0.000	0.000	0.026	0.114
Vicia americana	0.000	0.000	0.008	0.036

n = 18 1997, n = 20 1998

Table B.67. Percent ground cover by plant species on strip/no seed work in 1997 and 1998 at the Jenner South site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	0.002	0.005	0.000	0.000
Agropyron smithii	0.014	0.045	0.145	0.538
Agropyron trachycaulum	0.000	0.000	0.050	0.224
Bouteloua gracilis	0.155	0.369	0.220	0.725
Carex species	0.031	0.058	0.133	0.370
Distichlis stricta	0.000	0.000	0.003	0.011
Festuca seedling	0.000	0.000	0.020	0.089
Festuca ovina	0.000	0.000	0.060	0.268
Grass seedling	0.006	0.024	0.113	0.503
Koeleria macrantha	0.000	0.000	0.073	0.233
Amaranthus graecizans	0.121	0.354	0.000	0.000
Amaranthus retroflexus	0.000	0.000	1.321	1.109
Artemisia frigida	0.045	0.124	0.490	1.201
Chenopodium species	0.000	0.000	0.221	0.395
Chenopodium album	0.000	0.000	0.010	0.045
Cleome serrulata	0.000	0.000	0.030	0.134
Comandra umbellata	0.000	0.000	0.000	0.000
Descurainia sophia	0.000	0.000	0.012	0.054
Kochia scoparia	0.011	0.047	0.000	0.000
Lappula species	0.000	0.000	0.210	0.939
Malvacea coccinea	0.106	0.424	0.000	0.000
Oxytropis species	0.002	0.008	0.000	0.000
Phlox hoodii	0.002	0.009	0.000	0.000
Salsola kali	0.000	0.000	0.040	0.135
Symphoricarpos occidentalis	0.000	0.000	0.002	0.007

n = 18 1997, n = 20 1998

Table B.68. Percent ground cover by plant species on strip/seed spoil in 1997 and 1998 at the Jenner South site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	0.105	0.154	0.931	1.582
Agropyron smithii	0.119	0.196	0.840	1.747
Agropyron trachycaulum	0.000	0.000	0.923	2.261
Bouteloua gracilis	0.368	0.533	0.701	0.925
Calamagrostis montanensis	0.021	0.050	0.043	0.113
Carex species	0.247	0.362	0.937	1.673
Distichlis stricta	0.004	0.015	0.000	0.000
Festuca seedling	0.002	0.009	0.000	0.000
Festuca ovina	0.000	0.000	0.067	0.365
Koeleria macrantha	0.207	0.323	0.631	0.645
Muhlenbergia species	0.032	0.173	0.000	0.000
Poa species	0.001	0.005	0.000	0.000
Poa sandbergii	0.051	0.139	0.079	0.290
Stipa comata	0.126	0.379	0.565	1.413
Stipa curtiseta	0.185	0.446	1.254	2.059
Stipa viridula	0.002	0.012	0.000	0.000
Amaranthus graecizans	0.000	0.000	0.047	0.153
Amaranthus retroflexus	0.000	0.000	0.011	0.032
Anemone species	0.050	0.101	0.000	0.000
Anemone patens	0.001	0.007	0.197	0.349
Artemisia canadensis	0.061	0.257	0.000	0.000
Artemisia frigida	0.000	0.000	0.006	0.033
Artemisia ludoviciana	0.000	0.000	0.003	0.018
Chenopodium species	0.000	0.000	0.000	0.002
Geum trifolium	0.000	0.000	0.015	0.065
Haplopappus spinulosus	0.000	0.000	0.003	0.018
Lappula species	0.000	0.000	0.001	0.005
Malvacea coccinea	0.002	0.011	0.012	0.046
Phlox hoodii	0.001	0.004	0.046	0.136
Polygonum aviculare	0.000	0.000	0.040	0.219
Solidago missouriensis	0.068	0.372	0.000	0.000
Symphoricarpos occidentalis	0.000	0.000	0.030	0.164
Vicia americana	0.000	0.000	0.001	0.002
Weed seedling	0.000	0.000	0.002	0.009

n = 30

Table B.69. Percent ground cover by plant species on strip/seed trench in 1997 and 1998 at the Jenner South site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron seedling	0.0033	0.0183	0.000	0.000
Agropyron dasystachyum	0.0175	0.0294	0.569	1.059
Agropyron smithii	0.0016	0.0089	1.538	3.355
Agropyron trachycaulum	0.0187	0.0514	1.449	2.125
Bouteloua gracilis	0.0223	0.1223	0.000	0.000
Carex species	0.0030	0.0116	0.007	0.037
Festuca seedling	0.0003	0.0018	0.000	0.000
Festuca ovina	0.0000	0.0000	0.182	0.588
Grass seedling	0.0065	0.0169	0.002	0.009
Hordeum jubatum	0.0010	0.0055	0.000	0.000
Koeleria macrantha	0.0133	0.0267	0.036	0.138
Poa sandbergii	0.0000	0.0000	0.001	0.007
Stipa viridula	0.0000	0.0000	0.020	0.076
Amaranthus albus	0.0000	0.0000	0.024	0.086
Amaranthus graecizans	0.0000	0.0000	0.023	0.097
Amaranthus retroflexus	0.0000	0.0000	0.100	0.175
Artemisia frigida	0.0007	0.0026	0.172	0.461
Chenopodium species	0.0500	0.2739	0.145	0.715
Chenopodium album	0.0000	0.0000	0.004	0.022
Lappula species	0.0000	0.0000	0.003	0.018
Malvacea coccinea	0.0000	0.0000	0.002	0.011
Medicago sativa	0.0009	0.0051	0.000	0.000
Vicia americana	0.0000	0.0000	0.005	0.029

n = 30

Table B.70. Percent ground cover by plant species on strip/seed work in 1997 and 1998 at the Jenner South site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron seedling	0.000	0.000	0.003	0.018
Agropyron dasystachyum	0.065	0.192	1.351	2.423
Agropyron smithii	0.000	0.000	1.404	2.187
Agropyron trachycaulum	0.016	0.033	2.266	3.252
Bouteloua gracilis	0.032	0.110	0.239	0.638
Carex species	0.013	0.030	0.111	0.443
Festuca seedling	0.002	0.007	0.000	0.000
Festuca hallii	0.000	0.000	0.029	0.116
Festuca ovina	0.000	0.000	0.156	0.546
Grass seedling	0.006	0.019	0.000	0.000
Hordeum jubatum	0.000	0.000	0.016	0.088
Koeleria macrantha	0.011	0.027	0.071	0.244
Muhlenbergia cuspidata	0.003	0.016	0.000	0.000
Stipa comata	0.001	0.006	0.000	0.000
Stipa curtiseta	0.004	0.022	0.000	0.000
Stipa viridula	0.000	0.000	0.177	0.424
Achillea millefolium	0.000	0.000	0.007	0.037
Amaranthus albus	0.000	0.000	0.015	0.062
Amaranthus graecizans	0.000	0.000	0.061	0.210
Amaranthus retroflexus	0.000	0.000	0.030	0.065
Anemone species	0.098	0.361	0.000	0.000
Artemisia frigida	0.033	0.159	0.405	1.463
Astragalus pectinatus	0.003	0.008	0.000	0.000
Chenopodium species	0.000	0.000	0.003	0.015
Lappula species	0.000	0.000	0.023	0.128
Malvacea coccinea	0.009	0.035	0.181	0.694
Phlox hoodii	0.000	0.000	0.031	0.168
Rosa species	0.001	0.007	0.000	0.000
Solanum triflorum	0.000	0.000	0.007	0.040
Vicia americana	0.000	0.000	0.024	0.075
Weed seedling	0.000	0.001	0.000	0.000

n = 30

Table B.71. Percent ground cover by plant species on undisturbed prairie in 1997 and 1998 at the Jenner South site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	0.197	0.645	0.507	0.763
Agropyron smithii	0.022	0.045	0.087	0.179
Bouteloua gracilis	0.626	0.810	1.268	1.204
Calamagrostis montanensis	0.025	0.058	0.024	0.072
Carex species	0.542	1.028	0.840	1.165
Distichlis stricta	0.000	0.000	0.019	0.102
Koeleria macrantha	0.447	0.740	0.336	0.349
Muhlenbergia species	0.000	0.000	0.001	0.007
Poa sandbergii	0.412	0.689	0.042	0.139
Stipa comata	1.347	1.719	1.605	1.417
Stipa curtiseta	0.668	1.165	0.263	0.627
Stipa viridula	0.046	0.185	0.000	0.000
Achillea millefolium	0.004	0.018	0.013	0.073
Anemone patens	0.028	0.075	0.040	0.080
Arnica species	0.005	0.022	0.000	0.000
Artemisia canadensis	0.082	0.362	0.012	0.064
Artemisia frigida	0.107	0.308	0.157	0.296
Artemisia ludoviciana	0.000	0.000	0.005	0.029
Malvacea coccinea	0.011	0.027	0.032	0.080
Phlox hoodii	0.014	0.035	0.232	0.406
Symphoricarpos occidentalis	0.000	0.000	0.002	0.013
Vicia americana	0.000	0.000	0.012	0.037
Zygadenus gramineus	0.015	0.048	0.000	0.000

n = 30

Table B.72. Plant species density number per 0.1 meter square on no strip/no seed spoil in 1997 and 1998 at the Jenner South site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	0.600	1.329	3.633	4.687
Agropyron smithii	0.867	1.871	1.700	2.718
Agropyron trachycaulum	0.033	0.183	0.000	0.000
Bouteloua gracilis	1.867	2.700	1.967	2.632
Calamagrostis montanensis	0.533	1.008	0.733	1.437
Carex species	6.700	8.400	5.400	6.505
Koeleria macrantha	1.600	1.831	1.300	2.003
Poa sandbergii	0.767	1.794	0.133	0.434
Stipa comata	1.667	2.057	1.267	1.799
Stipa curtiseta	1.800	3.347	0.800	1.730
Amaranthus graecizans	0.000	0.000	0.033	0.183
Amaranthus retroflexus	0.000	0.000	0.467	2.193
Anemone species	0.167	0.531	0.133	0.434
Artemisia frigida	0.200	0.761	0.167	0.461
Chenopodium species	0.000	0.000	0.300	1.466
Haplopappus spinulosus	0.033	0.183	0.000	0.000
Lappula species	0.000	0.000	0.033	0.183
Malvacea coccinea	0.467	0.776	0.767	1.165
Phlox hoodii	1.500	2.556	0.933	2.196
Thermopsis rhombifolia	0.000	0.000	0.100	0.403
Weed seedling	0.033	0.183	0.000	0.000

n = 30

Table B.73. Plant species density number per 0.1 meter square on no strip/no seed trench in 1997 and 1998 at the Jenner South site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	0.000	0.000	0.033	0.183
Agropyron smithii	0.000	0.000	0.233	0.626
Agropyron trachycaulum	0.000	0.000	0.067	0.254
Poa sandbergii	0.000	0.000	0.033	0.183
Amaranthus graecizans	0.000	0.000	0.367	1.245
Amaranthus retroflexus	0.000	0.000	0.367	0.850
Artemisia frigida	0.000	0.000	0.167	0.461
Chenopodium species	0.000	0.000	0.167	0.461
Lappula species	0.000	0.000	0.033	0.183
Medicago sativa	0.000	0.000	0.067	0.254
Polygonum aviculare	0.000	0.000	0.033	0.183
Sisymbrium altissimum	0.000	0.000	0.033	0.183
Solanum triflorum	0.000	0.000	0.033	0.183

n = 30

Table B.74. Plant species density number per 0.1 meter square on no strip/no seed work in 1997 and 1998 at the Jenner South site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	0.267	0.583	2.233	2.359
Agropyron smithii	1.333	1.971	0.733	1.484
Bouteloua gracilis	2.767	2.921	1.933	2.149
Calamagrostis montanensis	0.467	1.137	0.700	1.343
Carex species	6.400	6.991	4.600	5.230
Festuca ovina	0.000	0.000	0.067	0.365
Koeleria macrantha	1.667	2.249	1.700	2.054
Poa sandbergii	1.333	3.651	0.500	0.938
Stipa comata	0.933	1.680	1.367	2.371
Stipa curtiseta	0.867	1.570	0.800	1.495
Stipa viridula	0.033	0.183	0.000	0.000
Achillea millefolium	0.033	0.183	0.000	0.000
Amaranthus graecizans	0.000	0.000	0.033	0.183
Amaranthus retroflexus	0.000	0.000	0.300	1.643
Anemone species	0.000	0.000	0.133	0.507
Anemone patens	0.067	0.254	0.000	0.000
Artemisia frigida	0.167	0.461	0.100	0.305
Chenopodium species	0.000	0.000	0.033	0.183
Malvacea coccinea	0.433	0.971	0.633	1.098
Opuntia polyacantha	0.033	0.183	0.000	0.000
Oxytropis species	0.000	0.000	0.000	0.000
Phlox hoodii	0.800	2.605	0.033	0.183

n = 30

Table B.75. Plant species density number per 0.1 meter square on no strip/seed spoil in 1997 and 1998 at the Jenner South site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	0.467	0.860	2.000	2.665
Agropyron smithii	3.033	3.429	5.833	6.929
Agropyron trachycaulum	0.000	0.000	0.200	0.551
Bouteloua gracilis	3.333	4.589	3.100	3.585
Calamagrostis montanensis	0.300	1.022	0.800	1.864
Carex species	4.400	6.393	8.067	8.183
Koeleria macrantha	1.100	1.583	1.233	1.942
Muhlenbergia species	0.000	0.000	0.033	0.183
Poa canbyi	0.000	0.000	0.067	0.365
Poa compressa	0.000	0.000	0.167	0.648
Poa pratensis	0.000	0.000	0.067	0.254
Poa sandbergii	1.067	2.377	0.633	0.964
Stipa comata	0.533	1.306	0.200	0.551
Stipa curtiseta	0.300	0.877	0.433	0.971
Stipa viridula	0.033	0.183	0.000	0.000
Amaranthus retroflexus	0.000	0.000	0.133	0.434
Anemone patens	0.100	0.403	0.167	0.461
Arenaria species	0.000	0.000	0.033	0.183
Artemisia canadensis	0.067	0.254	0.000	0.000
Artemisia ludoviciana	0.133	0.571	0.267	0.691
Aster ericoides	0.000	0.000	0.033	0.183
Astragalus pectinatus	0.133	0.434	0.000	0.000
Chenopodium species	0.000	0.000	0.067	0.365
Lappula species	0.000	0.000	0.067	0.365
Phlox hoodii	0.100	0.548	0.333	0.994
Thermopsis rhombifolia	0.033	0.183	0.033	0.183
Vicia americana	0.000	0.000	0.367	1.098

n = 30

Table B.76. Plant species density number per 0.1 meter square on no strip/seed trench in 1997 and 1998 at the Jenner South site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron seedling	0.067	0.365	0.000	0.000
Agropyron species	0.033	0.183	0.000	0.000
Agropyron dasystachyum	0.033	0.183	0.500	0.938
Agropyron smithii	0.033	0.183	0.900	1.561
Agropyron trachycaulum	0.067	0.254	1.133	1.106
Bouteloua gracilis	0.033	0.183	0.000	0.000
Festuca seedling	0.033	0.183	0.000	0.000
Festuca ovina	0.000	0.000	0.067	0.254
Grass seedling	0.100	0.548	0.167	0.648
Hordeum jubatum	0.000	0.000	0.067	0.254
Koeleria macrantha	0.300	0.702	0.067	0.365
Poa species	0.000	0.000	0.033	0.183
Poa sandbergii	0.000	0.000	0.133	0.346
Stipa curtiseta	0.000	0.000	0.033	0.183
Stipa viridula	0.067	0.254	0.067	0.254
Amaranthus species	0.000	0.000	0.067	0.365
Amaranthus graecizans	0.000	0.000	0.067	0.254
Amaranthus retroflexus	0.000	0.000	0.100	0.305
Artemisia frigida	0.000	0.000	0.067	0.254
Chenopodium species	0.000	0.000	0.433	1.331
Cirsium species	0.000	0.000	0.033	0.183
Descurainia sophia	0.000	0.000	0.033	0.183
Phlox hoodii	0.000	0.000	0.033	0.183
Portulaca oleracea	0.000	0.000	0.167	0.747
Sisymbrium altissimum	0.000	0.000	0.233	0.971
Solanum triflorum	0.000	0.000	0.033	0.183
Vicia americana	0.000	0.000	0.033	0.183
Weed seedling	0.000	0.000	0.100	0.305

n = 30

Table B.77. Plant species density number per 0.1 meter square on no strip/seed work in 1997 and 1998 at the Jenner South site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron seedling	0.167	0.747	0.000	0.000
Agropyron dasystachyum	1.000	1.762	1.367	2.266
Agropyron smithii	1.033	1.586	3.133	4.688
Agropyron trachycaulum	0.033	0.183	0.467	0.937
Bouteloua gracilis	3.700	3.905	2.367	3.222
Calamagrostis montanensis	0.333	0.758	0.867	1.676
Carex species	8.300	8.766	8.600	9.740
Festuca species	0.033	0.183	0.000	0.000
Festuca ovina	0.000	0.000	0.033	0.183
Koeleria macrantha	1.633	1.847	0.800	1.769
Poa sandbergii	0.300	0.877	1.300	1.860
Stipa comata	0.500	1.280	0.800	2.250
Stipa curtiseta	0.500	1.383	1.000	1.531
Stipa viridula	0.133	0.434	0.033	0.183
Amaranthus graecizans	0.000	0.000	0.133	0.346
Amaranthus retroflexus	0.000	0.000	0.267	1.048
Anemone species	0.067	0.365	0.133	0.571
Anemone patens	0.033	0.183	0.133	0.434
Arnica fulgens	0.000	0.000	0.033	0.183
Artemisia frigida	0.067	0.254	0.100	0.305
Artemisia ludoviciana	0.000	0.000	0.033	0.183
Aster laevis	0.000	0.000	0.133	0.571
Astragalus pectinatus	0.433	1.382	0.000	0.000
Chenopodium species	0.000	0.000	0.400	1.102
Kochia scoparia	0.100	0.548	0.000	0.000
Lappula species	0.000	0.000	0.067	0.365
Malvacea coccinea	0.167	0.592	0.100	0.403
Phlox hoodii	0.000	0.000	0.300	0.794
Portulaca oleracea	0.000	0.000	0.033	0.183
Solidago missouriensis	0.233	1.104	0.000	0.000
Thermopsis rhombifolia	0.000	0.000	0.067	0.254
Vicia americana	0.000	0.000	0.533	1.279
Weed seedling	0.000	0.000	0.067	0.254
Zygadenus gramineus	0.067	0.365	0.000	0.000

n = 30

Table B.78. Plant species density number per 0.1 meter square on strip/no seed spoil in 1997 and 1998 at the Jenner South site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	1.550	2.544	3.350	4.626
Agropyron smithii	2.700	2.452	5.550	9.886
Agropyron trachycaulum	0.000	0.000	0.100	0.308
Bouteloua gracilis	1.900	2.827	1.950	2.892
Calamagrostis montanensis	0.600	1.095	0.100	0.447
Carex species	19.200	23.581	7.400	9.795
Festuca ovina	0.000	0.000	0.050	0.224
Koeleria macrantha	1.650	1.954	0.900	1.373
Poa species	0.250	1.118	0.000	0.000
Poa sandbergii	1.150	2.621	0.250	0.910
Stipa comata	1.900	2.693	1.850	2.059
Stipa curtiseta	0.400	0.883	0.050	0.224
Amaranthus retroflexus	0.000	0.000	2.400	5.374
Anemone species	0.200	0.523	0.000	0.000
Anemone patens	0.050	0.224	0.250	0.786
Artemisia frigida	0.350	0.813	0.250	0.716
Artemisia ludoviciana	0.000	0.000	0.050	0.224
Chenopodium species	0.000	0.000	0.550	1.191
Descurainia sophia	0.000	0.000	0.050	0.224
Lappula species	0.000	0.000	0.050	0.224
Malvacea coccinea	0.350	0.813	0.450	1.276
Phlox hoodii	0.250	0.716	0.200	0.696
Polygonum aviculare	0.000	0.000	0.150	0.489
Rosa species	0.050	0.224	0.050	0.224
Salsola kali	0.000	0.000	0.050	0.224
Solanum triflorum	0.000	0.000	0.050	0.224
Symphoricarpos albus	0.200	0.696	0.000	0.000
Symphoricarpos occidentalis	0.000	0.000	0.350	0.745
Thermopsis rhombifolia	0.350	1.182	0.050	0.224
Vicia americana	0.000	0.000	0.300	1.342
Zygadenus species	0.150	0.671	0.000	0.000

n = 20

Table B.79. Plant species density number per 0.1 meter square on strip/no seed trench in 1997 and 1998 at the Jenner South site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	0.000	0.000	0.200	0.894
Agropyron smithii	0.000	0.000	0.050	0.224
Agropyron trachycaulum	0.000	0.000	0.400	0.821
Bouteloua gracilis	0.100	0.308	0.100	0.308
Calamovilfa longifolia	0.000	0.000	0.150	0.366
Carex species	0.200	0.696	0.650	1.182
Festuca ovina	0.000	0.000	0.150	0.671
Grass seedling	0.050	0.224	0.000	0.000
Hordeum jubatum	0.000	0.000	0.050	0.224
Koeleria macrantha	0.000	0.000	0.050	0.224
Poa species	0.000	0.000	0.050	0.224
Stipa comata	0.000	0.000	0.050	0.224
Stipa viridula	0.000	0.000	0.100	0.308
Amaranthus graecizans	0.100	0.308	0.000	0.000
Amaranthus retroflexus	0.000	0.000	17.400	14.887
Artemisia frigida	0.100	0.308	0.300	0.470
Astragalus pectinatus	0.100	0.447	0.000	0.000
Chenopodium species	0.000	0.000	2.300	4.330
Chenopodium album	0.000	0.000	0.050	0.224
Lappula species	0.000	0.000	0.050	0.224
Malvacea coccinea	0.000	0.000	0.050	0.224
Rosa species	0.100	0.308	0.000	0.000
Symphoricarpos albus	0.450	0.887	0.000	0.000
Symphoricarpos occidentalis	0.000	0.000	0.300	0.657
Thermopsis rhombifolia	0.050	0.224	0.050	0.224
Vicia americana .	0.000	0.000	0.050	0.224

n = 20

Table B.80. Plant species density number per 0.1 meter square strip/no seed work in 1997 and 1998 at the Jenner South site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	0.100	0.308	0.000	0.000
Agropyron smithii	0.200	0.696	0.300	0.801
Agropyron trachycaulum	0.000	0.000	0.050	0.224
Bouteloua gracilis	0.350	0.988	0.150	0.489
Carex species	1.200	2.949	0.350	0.813
Distichlis stricta	0.000	0.000	0.050	0.224
Festuca seedling	0.000	0.000	0.050	0.224
Festuca ovina	0.000	0.000	0.050	0.224
Grass seedling	0.100	0.447	0.100	0.447
Koeleria macrantha	0.000	0.000	0.200	0.523
Stipa viridula	0.050	0.224	0.000	0.000
Amaranthus graecizans	0.100	0.308	0.000	0.000
Amaranthus retroflexus	0.000	0.000	5.600	3.347
Artemisia frigida	0.200	0.523	0.150	0.366
Chenopodium species	0.000	0.000	1.950	3.441
Chenopodium album	0.000	0.000	0.050	0.224
Cleome serrulata	0.000	0.000	0.050	0.224
Descurainia sophia	0.000	0.000	0.050	0.224
Kochia scoparia	0.050	0.224	0.000	0.000
Lappula species	0.000	0.000	0.050	0.224
Malvacea coccinea	0.100	0.308	0.000	0.000
Oxytropis species	0.100	0.447	0.000	0.000
Phlox hoodii	0.050	0.224	0.000	0.000
Salsola kali	0.000	0.000	0.150	0.366
Symphoricarpos albus	0.050	0.224	0.000	0.000
Symphoricarpos occidentalis	0.000	0.000	0.050	0.224

n = 20

Table B.81. Plant species density number per 0.1 meter square strip/seed spoil in 1997 and 1998 at the Jenner South site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	1.667	1.845	2.900	5.756
Agropyron smithii	1.733	2.180	2.967	3.662
Agropyron trachycaulum	0.000	0.000	0.367	0.765
Bouteloua gracilis	2.833	3.544	1.867	2.193
Calamagrostis montanensis	0.533	0.937	0.467	1.196
Carex species	8.200	9.030	10.200	8.664
Distichlis stricta	0.200	0.761	0.000	0.000
Festuca seedling	0.033	0.183	0.000	0.000
Festuca ovina	0.000	0.000	0.067	0.365
Koeleria macrantha	1.767	2.161	1.767	1.755
Muhlenbergia species	0.100	0.548	0.000	0.000
Poa species	0.067	0.254	0.000	0.000
Poa sandbergii	0.567	1.524	0.167	0.531
Stipa comata	0.533	1.408	0.500	1.196
Stipa curtiseta	0.333	0.802	1.200	1.937
Stipa viridula	0.033	0.183	0.000	0.000
Amaranthus graecizans	0.000	0.000	0.267	0.740
Amaranthus retroflexus	0.000	0.000	0.267	0.740
Anemone species	0.400	0.724	0.000	0.000
Anemone patens	0.033	0.183	0.467	0.730
Artemisia canadensis	0.100	0.403	0.000	0.000
Artemisia frigida	0.000	0.000	0.100	0.403
Artemisia ludoviciana	0.000	0.000	0.033	0.183
Chenopodium species	0.000	0.000	0.033	0.183
Geum trifolium	0.000	0.000	0.067	0.254
Haplopappus spinulosus	0.000	0.000	0.033	0.183
Lappula species	0.000	0.000	0.033	0.183
Malvacea coccinea	0.033	0.183	0.067	0.254
Phlox hoodii	0.033	0.183	0.367	0.999
Polygonum aviculare	0.000	0.000	0.033	0.183
Solidago missouriensis	0.200	1.095	0.000	0.000
Symphoricarpos occidentalis	0.000	0.000	0.033	0.183
Vicia americana	0.000	0.000	0.067	0.254
Weed seedling	0.000	0.000	0.100	0.548

n = 30

Table B.82. Plant species density number per 0.1 meter square strip/seed trench in 1997 and 1998 at the Jenner South site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron seedling	0.133	0.730	0.000	0.000
Agropyron species	0.067	0.254	0.000	0.000
Agropyron dasystachyum	0.500	1.137	1.000	1.259
Agropyron smithii	0.033	0.183	1.333	2.294
Agropyron trachycaulum	0.300	0.535	0.933	0.868
Bouteloua gracilis	0.067	0.254	0.000	0.000
Carex species	0.067	0.254	0.067	0.365
Festuca seedling	0.033	0.183	0.000	0.000
Festuca ovina	0.000	0.000	0.367	0.556
Grass seedling	0.467	0.730	0.033	0.183
Hordeum jubatum	0.033	0.183	0.000	0.000
Koeleria macrantha	0.500	0.777	0.067	0.254
Poa sandbergii	0.000	0.000	0.033	0.183
Stipa viridula	0.000	0.000	0.067	0.254
Amaranthus albus	0.000	0.000	0.200	0.610
Amaranthus graecizans	0.000	0.000	0.100	0.403
Amaranthus retroflexus	0.000	0.000	4.400	8.732
Artemisia frigida	0.100	0.403	0.167	0.461
Astragalus pectinatus	0.033	0.183	0.000	0.000
Chenopodium species	0.033	0.183	0.467	2.193
Chenopodium album	0.000	0.000	0.033	0.183
Lappula species	0.000	0.000	0.033	0.183
Malvacea coccinea	0.000	0.000	0.033	0.183
Medicago sativa	0.033	0.183	0.000	0.000
Vicia americana	0.000	0.000	0.033	0.183

n = 30

Table B.83. Plant species density number per 0.1 meter square strip/seed work in 1997 and 1998 at the Jenner South site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron seedling	0.000	0.000	0.067	0.365
Agropyron dasystachyum	0.900	1.989	0.700	1.149
Agropyron smithii	0.000	0.000	1.133	2.080
Agropyron trachycaulum	0.233	0.568	0.733	0.980
Bouteloua gracilis	0.200	0.761	0.200	0.484
Carex species	1.033	2.930	0.667	2.023
Festuca seedling	0.133	0.434	0.000	0.000
Festuca hallii	0.000	0.000	0.100	0.305
Festuca ovina	0.000	0.000	0.167	0.379
Grass seedling	0.400	0.770	0.000	0.000
Hordeum jubatum	0.000	0.000	0.033	0.183
Koeleria macrantha	0.200	0.407	0.133	0.434
Muhlenbergia cuspidata	0.033	0.183	0.000	0.000
Stipa comata	0.100	0.403	0.000	0.000
Stipa curtiseta	0.033	0.183	0.000	0.000
Stipa viridula	0.000	0.000	0.233	0.430
Achillea millefolium	0.000	0.000	0.033	0.183
Amaranthus albus	0.000	0.000	0.067	0.254
Amaranthus graecizans	0.000	0.000	0.167	0.461
Amaranthus retroflexus	0.000	0.000	1.200	2.905
Anemone species	0.167	0.592	0.000	0.000
Artemisia frigida	0.100	0.305	0.133	0.346
Astragalus pectinatus	0.367	1.189	0.000	0.000
Chenopodium species	0.000	0.000	0.067	0.365
Lappula species	0.000	0.000	0.033	0.183
Malvacea coccinea	0.100	0.403	0.367	1.542
Phlox hoodii	0.000	0.000	0.133	0.730
Rosa species	0.033	0.183	0.000	0.000
Solanum triflorum	0.000	0.000	0.033	0.183
Vicia americana	0.000	0.000	0.333	1.295

n = 30

Table B.84. Plant species density number per 0.1 meter square in the undisturbed prairie in 1997 and 1998 at the Jenner South site.

	1997		1998	
Species	Mean	SD	Mean	SD
Agropyron dasystachyum	1.000	2.477	3.433	4.240
Agropyron smithii	0.433	1.040	1.100	2.551
Bouteloua gracilis	6.033	4.867	3.733	3.393
Calamagrostis montanensis	0.533	1.137	0.267	0.691
Carex species	12.767	10.391	15.533	13.069
Distichlis stricta	0.000	0.000	0.267	1.461
Koeleria macrantha	5.000	8.983	1.267	1.285
Muhlenbergia species	0.000	0.000	0.033	0.183
Poa sandbergii	3.567	4.256	0.233	0.626
Stipa comata	2.267	2.993	2.867	2.129
Stipa curtiseta	1.067	1.574	0.400	1.037
Stipa viridula	0.100	0.403	0.000	0.000
Achillea millefolium	0.067	0.254	0.100	0.548
Anemone patens	0.233	0.504	0.400	0.855
Arnica species	0.067	0.254	0.000	0.000
Artemisia canadensis	0.167	0.461	0.067	0.365
Artemisia frigida	0.400	0.621	0.700	1.055
Artemisia ludoviciana	0.000	0.000	0.067	0.365
Comandra umbellata	0.000	0.000	0.033	0.183
Malvacea coccinea	0.333	0.922	0.400	0.894
Phlox hoodii	0.333	0.844	2.767	4.083
Symphoricarpos occidentalis	0.000	0.000	0.033	0.183
Vicia americana	0.000	0.000	0.233	0.774
Zygadenus gramineus	0.167	0.461	0.000	0.000

n = 30

Table B.85. Ground cover summary by zone at the strip/no-strip experiment in 1997 and 1998.

Right-of-Way Zone	Ground cover parameter	1997		1998	
		Mean	SD	Mean	SD
Undisturbed prairie	Live vegetation	5.0	2.8	5.3	2.4
	Litter	14.6	24.5	19.7	28.3
	Bare ground	1.2	2.2	5.8	16.0
	Rock	0.0	0.0	0.0	0.1
	Moss	77.3	25.4	63.7	33.2
	Lichen	1.9	5.7	5.5	14.0
No-strip/no-seed spoil	Live vegetation	2.5	2.5	4.1	3.3
	Litter	4.0	12.6	4.7	6.7
	Bare ground	62.5	43.7	71.0	35.7
	Rock	0.2	0.3	0.5	0.9
	Moss	30.4	40.0	16.5	29.7
	Lichen	0.3	1.0	0.8	2.9
No-strip/no-seed trench	Live vegetation	0.0	0.1	1.7	3.5
	Litter	1.2	1.8	1.4	2.3
	Bare ground	98.6	1.8	95.4	4.6
	Rock	0.2	0.3	1.5	1.8
	Moss	0.0	0.0	0.0	0.3
	Lichen	0.0	0.0	0.0	0.0
No-strip/no-seed work	Live vegetation	3.5	3.4	7.0	4.5
	Litter	10.3	22.2	9.1	13.7
	Bare ground	65.4	38.6	71.8	28.0
	Rock	0.2	0.5	0.4	0.8
	Moss	20.6	34.5	11.7	24.3
	Lichen	0.1	0.4	0.0	0.1
No-strip/seed spoil	Live vegetation	2.2	2.4	5.6	3.8
	Litter	8.4	18.3	3.9	7.8
	Bare ground	75.7	36.1	77.5	31.6
	Rock	0.2	0.4	0.3	0.5
	Moss	12.7	28.1	12.4	29.3
	Lichen	0.8	2.9	0.5	3.2

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No-strip/seed trench	Live vegetation	0.1	0.1	2.2	2.0
	Litter	1.0	1.6	1.7	2.7
	Bare ground	98.6	1.7	95.3	3.5
	Rock	0.4	0.5	0.8	1.0
	Moss	0.0	0.0	0.0	0.0
	Lichen	0.0	0.0	0.0	0.0
No-strip/seed work	Live vegetation	2.6	2.4	7.0	4.5
	Litter	10.6	19.4	5.6	13.2
	Bare ground	70.1	34.5	74.7	27.4
	Rock	0.2	0.8	0.1	0.3
	Moss	16.4	27.1	12.6	24.0
	Lichen	0.1	0.3	0.1	0.3
Strip/no-seed spoil	Live vegetation	2.3	2.2	7.2	3.2
	Litter	10.3	27.3	7.0	9.1
	Bare ground	58.6	45.3	76.7	27.6
	Rock	0.4	0.1	0.2	0.4
	Moss	28.7	34.1	8.9	26.7
	Lichen	0.0	0.2	0.0	1.0
Strip/no-seed trench	Live vegetation	0.2	0.4	2.0	2.4
	Litter	0.8	1.7	2.4	4.4
	Bare ground	98.7	1.7	94.8	5.0
	Rock	0.3	0.3	0.7	1.3
	Moss	0.0	0.3	0.1	0.6
	Lichen	0.0	0.0	0.0	0.0
Strip/no-seed work	Live vegetation	0.3	0.5	2.1	2.1
	Litter	0.5	1.2	1.5	6.1
	Bare ground	98.8	1.3	95.3	6.5
	Rock	0.3	0.4	0.9	1.4
	Moss	0.0	0.0	0.3	0.7
	Lichen	0.0	0.0	0.0	0.0
Strip/seed spoil	Live vegetation	2.0	3.2	5.4	3.7
	Litter	1.9	5.3	3.2	6.4
	Bare ground	79.1	34.1	75.6	35.4
	Rock	0.2	0.3	0.4	0.8
	Moss	16.7	32.3	15.0	31.6
	Lichen	0.1	0.4	0.3	1.3

Strip/seed trench	Live vegetation	0.2	0.4	3.4	3.1
	Litter	0.6	0.6	1.3	1.7
	Bare ground	99.0	0.8	94.7	3.4
	Rock	0.2	0.3	0.6	0.9
	Moss	0.0	0.0	0.1	0.3
	Lichen	0.0	0.0	0.0	0.0
Strip/seed work	Live vegetation	0.3	0.7	4.6	4.6
	Litter	0.9	1.6	1.2	2.0
	Bare ground	98.5	1.6	93.6	5.2
	Rock	0.2	0.3	0.6	1.1
	Moss	0.0	0.3	0.1	0.3
	Lichen	0.0	0.0	0.0	0.0

n = 60

Table B.86. Seeded grasses at the Jenner North strip/no-strip research site.

Grass species	Seeding rate (PLS/m^2)
streambank wheatgrass (*Agropyron riparium*)	30
northern wheatgrass (*Agropyron dasystachyum*)	16
western wheatgrass (*Agropyron smithii*)	16
slender wheatgrass (*Agropyron trachycaulum*)	36
prairie sand reed (*Calamovilfa longifolia*)	80
green needlegrass (*Stipa viridula*)	50
indian ricegrass (*Oryzopsis hymenoides*)	150
sheep fescue (*Festuca ovina*)	150
Canada bluegrass (*Poa compressa*)	250
junegrass (*Koeleria macrantha*)	130

PLS: pure live seed (% purity × % germination).

Table B.87. Seeded grasses at the Jenner South strip/no-strip research site.

Grass species	Seeding rate (PLS/m^2)
western wheatgrass (*Agropyron smithii*)	20
slender wheatgrass (*Agropyron trachycaulum*)	22
streambank wheatgrass (*Agropyron riparium*)	61
northern wheatgrass (*Agropyron dasystachyum*)	24
green needlegrass (*Stipa viridula*)	80
sheep fescue (*Festuca ovina*)	200
junegrass (*Koeleria macrantha*)	200
alkali bluegrass (*Poa juncifolia*)	200

PLS: pure live seed (% purity × % germination).

Table B.88. Seeded grasses at the Hardisty sod salvage research site.

Grass species	Seeding rate (PLS/m^2)
streambank wheatgrass (*Agropyron riparium*)	28
northern wheatgrass (*Agropyron dasystachyum*)	28
western wheatgrass (*Agropyron smithii*)	20
slender wheatgrass (*Agropyron trachycaulum*)	48
green needlegrass (*Stipa viridula*)	170
junegrass (*Koeleria macrantha*)	320
sheep fescue (*Festuca ovina*)	300
plains rough fescue (*Festuca hallii*)	360

PLS: pure live seed (% purity × % germination).

Table B.89. Seeded grasses at the Manyberries sod salvage research site.

Grass species	Seeding rate (PLS/m^2)
streambank wheatgrass (*Agropyron riparium*)	16
northern wheatgrass (*Agropyron dasystachyum*)	16
western wheatgrass (*Agropyron smithii*)	12
slender wheatgrass (*Agropyron trachycaulum*)	40
green needlegrass (*Stipa viridula*)	50
indian ricegrass (*Oryzopsis hymenoides*)	60
junegrass (*Koeleria macrantha*)	120
plains rough fescue (*Festuca hallii*)	180

PLS: pure live seed (% purity × % germination).